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尿素石膏鎂複合肥料對水稻之肥效試驗[1]

楊 遜 謙[2]

一、前 言

稻作增產途徑，除了改良品種爲重要因素之一外，施用肥料仍爲最有效方法。近年來正致力於水稻單位面積產量之提高，因此施肥量一再增加，如氮素每公頃施用量已達160 公斤以上，但所得結果尙不如理想，因肥料之性質、施用時期、栽培品種、氣候、生育環境及發育過程之不同，均能影響肥料之效果。據報告氮肥施用後其流失高達50%，而實際利用率則只有20～30%。換言之，氮素施用後其利用率在50%以下。考其原因，係作物吸收能力，以及氮素轉成硝酸態速度與作物吸收產生不均衡所致。爲防止上述現象，在日本已普遍使用粒態緩效性複合肥料，並得良好效果。

本省在水稻肥料方面尙未有上述肥料之普遍供應，只大揚化學公司出品之晶體尿素石膏鎂複合肥料。本試驗係探討晶體尿素石膏鎂複合肥料對於水稻生育及產量之效果。

二、試 驗 方 法

本試驗供試品種爲臺南5號，民國59年第1、2期作，在嘉義農業試驗分所農場舉行。所用肥料種類爲(1)氮肥三種，硫酸錏（N 21%），尿素（N 46%），尿素石膏鎂（N 18%，鎂4%）。(2)磷肥用過磷酸鈣（P_2O_5 18%），(3)鉀肥用氯化鉀（K 60%）。試驗採隨機區組設計，3種肥料，3種肥料量，計9處理，加對照處理(CK)共10處理，重複6次，小區面積 $2.5m \times 4m = 10m^2$，合 $\frac{1}{1000}$ 公頃。肥料使用量：（公斤/公頃）

N	80	120	160
P	72	72	72
K	72	72	72

肥料處理別如下：

（1）尿素石膏鎂 80公斤。
（2）尿素石膏鎂120公斤。
（3）尿素石膏鎂160公斤。
（4）硫酸錏 80公斤。
（5）硫酸錏120公斤。
（6）硫酸錏160公斤。
（7）尿素 80公斤。
（8）尿素120公斤。
（9）尿素160公斤。
（10）硫酸錏120公斤（CK）。

施肥時期及比例列於下表：

肥料種類	基肥（%）	第一次追肥 插秧後 I期15日 II期10日	第二次追肥 插秧後 I期30日 II期20日	穗肥 插秧後 I期74日 II期45日	備註
尿素石膏鎂	25	25	30	20	
硫酸錏	25	25	30	20	
尿素	25	25	30	20	
硫酸錏(CK)	25	—	40	35	N120,P72,K72
磷肥	100	—	—	—	
鉀肥	50	—	50	—	

在試驗進行時承張主任萬來之指導及本文之校正，謹此致謝。

1.試驗報告農試字第五八二號 2.臺灣省農業試驗所嘉義分所技士

三、試驗結果與檢討

表一、不同肥料處理對稻谷產量之影響

處理	59年第1期作			59年第2期作		
	產量 kg/ha	指數	順次	產量 kg/ha	指數	順次
1.尿素石膏鎂 80kg/ha	5,505	87.4	8	3,857.9	92.8	8
2.尿素石膏鎂 120kg/ha	6,319	100.3	4	4,271.9	102.8	4
3.尿素石膏鎂 160kg/ha	7,092	112.5	1	4,765.1	114.6	1
4.硫酸錏 80kg/ha	4,976	79.0	10	3,584.3	86.2	10
5.硫酸錏 120kg/ha	6,019	95.5	6	4,108.3	98.8	6
5.硫酸錏 160kg/ha	6,808	108.0	2	4,550.5	109.5	2
7.尿素 80kg/ha	4,997	79.3	9	3,586.9	86.3	9
8.尿素 120kg/ha	5,672	90.0	7	3,966.6	95.4	7
9.尿素 160kg/ha	6,521	103.5	3	4,284.8	103.1	3
10.硫酸錏 120kg/ha	6,302	100	5	4,157.2	100	5

表二、產量變方分析表

變因	自由度	59年第1期作			59年第2期作		
		平方和	均方和	F值	平方和	均方和	F值
區集	5	600,441.13	120,088.25	1.77	864,675.93	172,935.19	4.16**
處理	(9)	28,279,941.26	3,142,215.70	46.44**	7,896,808.91	877,423.21	21.09**
肥料種類	2	3,065,197.00	1,532,598.50	22.65**	1,136,761.39	568,380.70	13.66**
肥料量	2	24,438,210.33	12,219,105.17	180.60**	6,612,528.31	3,306,264.16	79.48**
肥料種類 肥料量	4	251,250.67	62,812.67	0.93	134,680.89	33,670.22	0.81
處理對CK	1	525,283.27	525,283.27	7.76**	12,838.32	12,838.32	0.31
機差	45	3,044,673.54	67,659.41	—	1,871,894.01	41,597.64	—
總計	59	31,925,055.93	—	—	10,633,378.85	—	—

表三、不同肥料之產量比較

	肥料種類	平均產量 kg/ha		
第一期作	尿素石膏鎂	6,305		
	硫酸錏	5,934	371 *	
	尿素	5,730	575 **	204

	肥料種類	平均產量 kg/ha		
第二期作	尿素石膏鎂	4,298.3		
	硫酸錏	4,081.0	217.3	
	尿素	3,946.1	352.2 **	134.9

由表一、及表三、所示，肥料種類與肥料用量間有極明顯之差異，即肥料種類中以尿素石膏鎂爲佳，次爲硫酸錏，再次爲尿素等順序。肥料用量以每公頃施用N160公斤者產量最高，肥料用量間之差異達極顯著水準。同樣肥料用量中又以尿素石膏鎂產量最高，考其原因，可能爲晶體複合肥料在水田中不易流失，肥料有效利用率較高之故。根據田間觀察結果，肥料施用後，尿素、硫酸錏爲速效性，數日即見效，並葉色較濃，但尿素石膏鎂則呈緩效性效果，葉色較上二者稍淡，持續性較久。

表四、不同肥料量之產量比較

	肥料量	平均產量 kg/ha		
第一期作	160	6,807		
	120	6,003	804 **	
	80	5,159	1,648 **	844 **

	肥料量	平均產量 kg/ha		
第二期作	160	4,533.4		
	120	4,115.6	417.8 **	
	80	3,676.4	857.0 **	439.2 **

表五、不同肥料處理對產量構成因素之影響

處理	59年第1期作				59年第2期作			
	穗數	一穗粒數	千粒重	稔實率	穗數	一穗粒數	千粒重	稔實率
1.尿素石膏鎂 80kg/ha	14.1	109.4	27.3	95.2	9.4	126.9	27.3	89.8
2.尿素石膏鎂 120kg/ha	15.9	92.7	27.0	95.2	9.2	134.7	27.7	86.8
3.尿素石膏鎂 160kg/ha	19.6	95.0	27.0	93.5	11.8	138.7	26.7	85.8
4.硫酸錏 80kg/ha	13.4	106.1	27.7	95.3	8.8	130.0	27.4	88.3
5.硫酸錏 120kg/ha	15.7	100.8	27.3	95.1	9.6	137.5	27.1	86.4
6.硫酸錏 160kg/ha	17.5	98.8	28.0	95.1	11.1	128.8	27.1	86.9
7.尿素 80kg/ha	12.4	101.1	27.0	94.7	8.3	131.9	27.4	87.6
8.尿素 120kg/ha	14.3	99.2	26.3	95.9	9.8	136.5	27.4	84.8
9.尿素 160kg/ha	16.0	98.5	27.0	95.3	10.6	131.9	27.0	87.8
10.硫酸錏 120kg/ha	15.5	102.2	27.3	94.4	10.4	131.2	26.9	85.9

產量構成因子中，直接影響產量者仍爲穗數之增加，在各肥料處理間，不難看出同一種肥料之間，仍爲N160公斤者穗數高於 N 120、N 80 。又同一肥料用量中，以尿素石膏鎂、硫酸錏、尿素等由肥料用量之增加，穗數亦隨著增加。在表中不同肥料用量，亦以尿素石膏鎂之穗數較其他肥料爲優。

表六、不同肥料處理對主要農藝性狀之影響

處理	59年第1期作					59年第2期作				
	株高(cm)	分蘖(支)	生育日數(日)	穗長(cm)	穗重(g)	株高(cm)	分蘖(支)	生育日數(日)	穗長(cm)	穗重(g)
1.尿素石膏鎂 80kg/ha	95.3	22.0	95.5	20.8	3.00	96.5	15.4	64.7	20.2	3.22
2.尿素石膏鎂 120kg/ha	98.5	23.2	95.8	19.4	2.53	98.5	15.6	65.5	20.4	3.36
3.尿素石膏鎂 160kg/ha	102.5	23.1	96.8	19.9	2.60	101.3	17.7	66.3	20.8	3.30
4.硫酸錏 80kg/ha	92.8	23.0	95.2	20.5	2.93	94.2	15.3	65.3	20.1	3.30
5.硫酸錏 120kg/ha	97.7	23.9	95.3	20.3	2.93	98.6	16.7	65.3	20.8	3.34
6.硫酸錏 160kg/ha	101.8	26.3	95.5	20.2	2.73	100.3	17.2	65.8	20.6	3.22
7.尿素 80kg/ha	93.2	21.1	95.7	20.2	2.80	94.1	13.9	65.2	20.3	3.32
8.尿素 120kg/ha	96.5	21.6	96.5	20.2	2.77	96.7	15.8	65.8	20.4	3.32
9.尿素 160kg/ha	101.0	23.5	95.2	19.9	2.63	98.2	16.6	66.2	20.4	3.22
10.硫酸錏 120kg/ha	97.4	25.4	94.7	20.5	2.80	97.5	16.1	66.2	20.7	3.20

在表六、所示，株高在重肥區較高；不同肥料間，則尿素石膏鎂處理區較硫酸錏、尿素區略高。分蘖亦依肥料增加之順序而增加分蘖數。生育日數處理間尚無甚差異。

四、討　　論

根據產量分析結果，不同肥料處理間之差異達極顯著水準，產量最高者爲尿素石膏鎂 160公斤，硫酸錏160公斤次之，尿素160公斤列第三位；而一、二期作表現相同，均以重肥區之產量爲高。由處理成分分析，得知肥料種類間之差異達極顯著水準，尿素石膏鎂、硫酸錏、尿素等順序顯示其肥效不一。又肥料施用量間之差異亦極爲顯著，160公斤/公頃處理顯較其他處理高產。就產量構成因素資料獲知，穗數之增加顯爲導致增產之主要原因。尿素石膏鎂之肥效較佳，似與其分解速度有關。在田間觀察，獲知尿素石膏鎂使用後其固形晶體在田間分解緩慢，持續性長久，而一般稻田中施用硫酸錏及尿素後溶解較速。在此種情形下，若土壤保水力差或氣候變化，水稻一時無法吸收，或者逢降雨則易於流失，以及其溶解揮發擴散等，皆足以減少肥效。尿素石膏鎂可防止上述情形，且因含有石膏及鎂等，並可改善土讓之理化性質，由此可知尿素石膏鎂具有較優肥效之原因。又本試驗舉行地點爲本分所台斗坑試驗地，原屬土壤較瘠之看天田，因此水稻對肥料之反應較爲明顯，所得結果當較具可靠性。

五、摘　　要

1. 本試驗爲測定尿素石膏鎂肥料對水稻之效果，採用隨機區組設計，三種肥料（尿素石膏鎂、硫酸錏、尿素）三種肥料量（80公斤、120公斤、160公斤）計得九處理，加對照區共十處理，重複六次，小區面積$2.5m \times 4m = 10m^2$，合$\frac{1}{1000}$公頃。
2. 根據試驗分析結果，不同肥料處理間之差異達極顯著水準。產量最高者爲尿素石膏鎂 160公斤，次爲硫酸錏160公斤，尿素列第三。又肥料種類間之差異亦極顯著。
3. 由產量構成因素資料分析，在各處理中可發現穗數爲產量增加最大之原因。
4. 初步試驗結果顯示尿素石膏鎂爲一高度有效之稻田肥料。

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EFFECT OF MAGYPSUM UREA ON RICE

S. C. Yang

Summary

1. This experiment was conducted in both crops of 1970 at the Chiayi Agricultural Experiment Station to evaluate the effect of Magypsum urea on the growth of rice. The variables included 3 types of fertilizer (Magypsum urea, Ammonium sulfate, and urea) and 3 doses of fertilizer (80, 120, and 160 kg per ha) with a total of 9 treatments which was arranged in a randomized complete block design with 6 replications. The plot size was 2.5×4m which was equivalent to $\frac{1}{1,000}$ ha.
2. It was observed that difference among doses of fertilizer was significant at 1% level. Magypsum urea applied at 160 kg per ha afforded the highest yield, ammonium sulfate applied at 160 kg per ha came next, and urea applied at 160 kg per ha ranked third. Difference among types of fertilizer was also significant at the 1% level of probability.
3. From the data of yield components, it was noted that the number of panicles per hill was the major component that contributed to the yield increase.
4. The result of this experiment seems to indicate that magypsum urea is a highly effective fertilizer for paddy rice.

EFFECT OF SOIL TREATMENT ON THE EMERGENCE AND GROWTH OF WEEDS AND RICE[1]

W. L. Chang and C. P. Mao[2]

Although good control of weeds in rice can be available through the use of herbicides, chemical control of weeds is still considered expensive at the present circumstances. There is also a growing concern that continuous application of herbicides in rice may create a serious residue problem in the future. It is desirable, therefore, that weeds in rice can be controlled by a relatively cheap and safe method. Soil treatment appears promising as a physical method of controlling weeds in transplanted rice.

Raising seedlings for rice transplanter is quite difficult in the first crop when temperature is low. Rice seeds and seedlings are easily attacked by soil pathogens under cold environmental conditions, resulting in the seed decay and wilting of seedlings. Application of fungicides is not only expensive but provides only partial solution to the problem. Soil treatment of the nursery bed may give a better protection for rice seeds and young seedlings from the attack of soil pathogens. This paper reports the emergence and growth of weeds and rice as affected by the physical treatment of soil.

MATERIALS AND METHODS

The experiment was conducted on the clay pots in the screenhouse of the Chiayi Agricultural Experiment Station in the first crop of 1972. Soil samples taken from rice field were thoroughly burned with wood fire until the color of the soil became red. The burned and unburned soil samples were put into clay pots with surface area of 250 cm^2. Part of the soil samples was also sent to the soil testing laboratory of the Tainan District Agricultural Improvement Station for making soil analysis. The results of soil analysis were presented in Table 1.

Table 1. Results of the soil analysis.

Treatment	Texture	pH	Organic matter (%)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Burned Soil	Sandy loam	6.7	0.07	772	430
Unburned Soil (CK)	Sandy loam	5.4	1.82	830	67

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Seeds of an indica rice variety, Taichung shen 2 and three major weeds in rice field namely, *Echinochloa crusgalli*, *Monochoria vaginalis*, and *Cyperus difformis* were planted in each clay pot. The number of seeds planted in each pot was 100 for both rice and *Echinochloa crusgalli* whereas 200 seeds were grown for both *Monochoria vaginalis* and *Cyperus difformis*. The seeds were planted on January 10, 1972. The experiment was arranged in a randomized complete block design with two replications. The percentage of germination was recorded for rice and weeds. Temperature during the period of germination is shown in Table 2. The growth of rice and weeds was expressed by the plant height and number of tillers per plant taken at 70 days after seeding.

Table 2. Climatic data during the period of seed germination.

Period	Temperature °C			Period	Temperature °C		
	Max.	Min.	Mean		Max.	Min.	Mean
Jan. 11 — 15	18.7	10.5	14.6	Feb. 1 — 5	25.6	17.6	21.6
16 — 20	20.9	11.2	16.1	6 — 10	18.1	11.6	14.9
21 — 25	25.6	15.4	20.5	11 — 15	19.2	12.3	15.8
26 — 31	23.0	14.0	18.5	16 — 20	25.4	16.2	20.8

RESULTS AND DISCUSSION

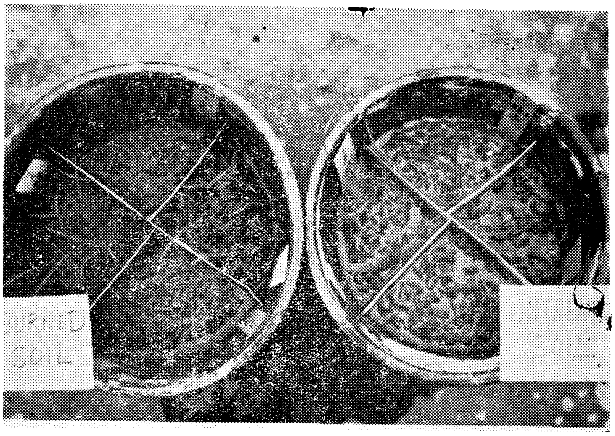
Germination of Weeds and Rice

The number of days required for seeds of weeds and rice to germinate and the percentage of germination for weeds and rice are presented in Talbe 3. It was observed that the germination on the unburned soil took 9, 14, and 21 days for *Echinochloa crusgalli*, *Cyperus difformis* and *Monochoria vaginalis*, respectively. The result shows that three major weeds of rice differ considerably in their days to germination. Rice variety Taichung shen 2 germinated as early as *Echinochloa crusgalli*. The number of days to germination in the treatment of burned soil was the same as that in the untreated control for *Echinochloa crusgalli* and *Cyperus difformis*, indicating that the days to germination of these two weeds is not affected by the physical treatment of the soil. It was noted, however, that *Monochoria vaginalis* took 39 days to germinate on the burned soil while the germination took only 21 days on the unburned soil. This indicates that the germination of *Monochoria vaginalis* can be considerably delayed if it is grown on the soil that has been burned. The days to germination for rice was also not affected by the soil treatment.

Table 3. Germination of weeds and rice.

	Days to germination		Percentage of germination (%)	
	Burned soil	Unburned soil	Burned soil	Unburned soil
Echinochloa crusgalli	9	9	38.0	38.0
Monochoria vaginalis	39	21	0.5	16.0
Cyperus difformis	14	14	1.5	63.0
Rice	8	8	98.0	41.0

The percentage of germination in the burned soil was the same as that in the unburned soil for *Echinochloa crusgalli*, showing that the germination of this weed was not affected by the soil treatment. It was observed, however, that there was practically no germination of seeds for *Cyperus difformis* and *Monochoria vaginalis* on the burned soil while as much as 63 and 16% of these weeds germinated on the untreated soil (Table 3) . The Figure 1. also provides a clear picture of this situation. It can be seen in Figure 1. that spaces allotted for both *Cyperus difformis* and *Monochoria vaginalis* in the burned soil were almost free from weeds while quite a few weeds germinated in the untreated soil. This observation clearly demonstrates that soil which has been burned seems to contain substances with inhibitory effect to germination of certain weeds of rice. The result of soil analysis shows that the burned soil has higher pH value and available K_2O but contained very low organic matter when compared with those of the unburned soil. It is, however, not clear whether these changes in soil property are related to the inhibitory effect of the burned soil on the germination of weed seeds. Nevertheless, the finding that weed emergence was suppressed on the burned soil might be of great practical significance. It appears likely that considerable reduction in the population density of weeds, if not complete control of weeds, can be obtained in rice through the burning of soil or the application of burned soil in rice field. This approach may turn out to be a cheap and effective physical method of weed control in rice since *Monochoria vaginalis* and *Cyperus difformis* are usually the predominant weeds of rice (Chang, 1971) . In rice fields not



Burned soil Unburned soil

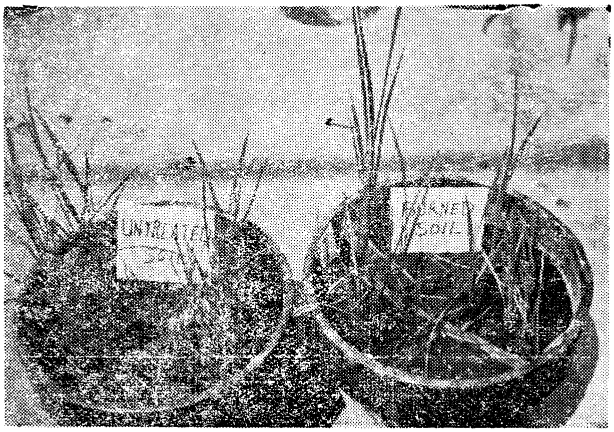
Figure 1. Germination of weeds and rice.

heavily infested with weeds, a satisfactory weed control should be possible with herbicides applied at lower rates, resulting in a considerable saving of the cost of chemical control (Chang and De Datta, 1972) . Further investigation on the usefulness of this method appears worthwhile.

The germination of rice variety Taichung shen 2 was quite normal on burned soil with percentage of germination reached as high as 98%. In the control treatment, however, only 41% of rice seeds germinated (Table 3) . The failure of most rice seeds to germinate on the unburned soil may be attributable to seed decay caused by soil pathogens. The symptom of seed rot can also be seen in Figure 1, where space allotted for rice in the unburned soil was almost covered with black mold. There was no evidence of seed decay in the burned soil presumably most of harmful soil organisms has been killed during the process of burning. Soil pathogens not only destroyed rice seeds but also killed most of rice seedlings before they became ready for transplanting. The temperature during the period of germination was generally low (Table 2) . Since seed decay rarely becomes a problem in the hot second crop, it appears that rice seeds are more susceptible to seed decay under cold environmental condition. The seed decay and wilting of seedlings pose a serious problem to nursery management for rice transplanter where rapid seed germination and uniform seedling growth are required for the smooth operation of the transplanting machine. Although seed decay and seedling wilting can be controlled to some extent by the application of fungicides such as Tachigaren (Chien and Hung, 1971) , the burning of nursery soil may offer a cheaper and better solution to this problem. Of course, possibilities of developing rice varieties with better ability to germinate and good resistance to soil organisms under unfavorable low temperature condtions should also be fully explored.

Growth of Weeds and Rice

The growth of weeds and rice was expressed by plant height and number of tillers per plant recorded at 70 days after seeding (Table 4) . Plant height and number of tillers per plant of *Echinochloa crusgalli* were quite similar in both burned and unburned soils, indicating that the growth of this weed was not affected by soil treatment during the early growing stage. The growth of *Monochoria vaginalis* and *Cyperus difformis* in the burned soil was poorer than that in the unburned soil since values of plant height and number of leaves per plant of these two weeds



Unburned soil Burned soil

Figure 2. Growth of weeds and rice.

in the burned soil was considerably smaller than those in the unburned soil. The plant height of rice variety Taichung shen 2 in the burned soil was also shorter than that in the unburned soil (Figure 2), although number of tillers per plant was the same in both soil treatments. Obviously, the growth of *Monochoria vaginalis*, *Cyperus difformis*, and rice variety, Taichung shen 2 can be affected by the burning of soil at least during the early growing stage. The exact reason for the burned soil to suppress the growth of certain weeds and rice is, however, not presently clear. It can be seen that the burned soil contained a verylow amount of organic matter (Table 1) and this might affect the growth of certain weeds and rice. Also, rice soil was found to became more compact after the burning which may render penetration and development of root in the soil increasingly difficult. Accordingly, less nutrients could be absorbed from the burned soil which might contribute to the poor growth of weeds and rice. This should be taken into consideration when the burned soil is to be used in the control of weeds in rice field and seedling disease in the nursery box of the rice transplanter.

Table 4. Growth of weeds and rice.

	Plant height (cm)		Number of Tillers per Plant	
	Burned soil	Unburned soil	Burned soil	Unburned soil
Echinochloa crusgalli	16.4	15.8	1.0	1.0
Monochoria vaginalis	1.0	4.2	1.5*	5.0*
Cyperus difformis	2.3	4.7	1.5*	2.2*
Rice	9.4	12.7	1.0	1.0

*Number of leaves per plant.

SUMMARY

Preliminary results on the emergence and growth of weeds and rice as affected by the burning of soil obtained at the Chiayi Agricultural Experiment Station in the first crop of 1972 are reported. The germination and early growth of *Echinochloa crusgalli* were not affected by the burning of the soil while *Monochoria vaginalis* and *Cyperus difformis* showed poor germination and growth on the burned soil. Rice variety Taichung shen 2 germinated poorly and developed severe seedling disease on the untreated soil but seed germination and seedling growth were apparently normal on the burned soil, although there was evidence of slight suppression on the seedling height.

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土壤處理對雜草及水稻萌芽與生長之影響

張 萬 來　　毛 振 鵬

摘　　要

本文係報告嘉義農業試驗分所在民國61年第 1期觀察土壤處理對若干什草及水稻萌芽及初期生長影響所得之初步結果。稗草之發芽及初期生長未受土壤處理之影響，惟鴨舌草及球花蒿草在燒土上之發芽及初期生長均較未處理者爲劣。水稻品種臺中秈 2號在未處理土壤上之發芽不良，且發生嚴重立枯病，惟在燒土上之發芽良好，秧苗生長雖稍受抑制，但尚稱正常。

RESIDUAL EFFECT OF HERBICIDES ON THE SUCCEEDING CROP OF RICE[1]

W.L. Chang[2]

Recent introduction of herbicides for controlling weeds in transplanted rice in Taiwan has prompted speculation concerning the possible residual effect of these chemicals on the performance of the succeeding crops. It is a matter of great concern to rice workers in view of the rapid increase in the use of herbicides in recent years. In 1971, the acreage of chemical control of weeds in rice exceeded 50,000 ha while only 15,000 ha of rice field was controlled with herbicides in 1970 (Chang, 1971). It appears worthwhile, therefore, to understand the role played by herbicide residues in the transplanted rice. The objectives of this investigation were to compare the infestation of weeds and the growth of rice in the paddy field treated with various herbicides in the second crop, 1971.

MATERIALS AND METHODS

This experiment was conducted in the first crop of 1972 at the Wan-tien-li farm of the Chiayi Agricultural Experiment Station. Japonica rice variety, Chianung 242 was transplanted in the paddy field which was subjected to 11 herbicide treatments in the previous crop, the second crop of 1971 (Table 1). The original experimental plots as well as experimental design were employed. The plant spacing was 25×20 cm with approximately five seedlings being transplanted in each hill. Fertilizers were applied at the rate of 120,60, and 60 kg per ha for N, P_2O_5, and K_2O, respectively. Weed count was made at one and two months after transplanting of rice. Plant height and number of tillers per hill at 60 days after transplanting, days to heading, plant height and number of panicles per hill at maturity stage and grain yield of rice were recorded for the analysis of variance.

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1. Serial No. (Q) 584. This experiment was supported in part by the National Science Council (NSC) and the Joint Commission on Rural Reconstruction (JCRR) under the project number of 72—All—A—2228 (NSC).

2. Agronomist, Chiayi Agricultural Experiment station, TARI.

Table 1. Herbicide treatments of the second crop, 1971.

Treatment number	Herbicide treatment	Formulation concentration (%)	Rate of application (kg/ha active ingredient)	Time of application (DAT)
1	2,4—D IPE (G)	3.2	0.8	4
2	CP 53619 (G)	5	1.0	4
3	CP 53619/2,4—D BE (G)	3.3/1.67	1.0/0.5	4
4	Benthiocarb (G)	10	1.0	4
5	Benthiocarb (G) +2,4—D IPE (G)	10+3.2	1.0+0.5	4
6	C—285 (G) +2,4—D IPE (G)	7.5+3.2	0.75+0.5	4
7	C—288 (G) +2,4—D IPE (G)	7.5+3.2	0.75+0.5	4
8	NTN 5006/2,4—D IPE (G)	7.0/1.5	2.0/0.45	4
9	C—290 (G) +2,4—D IPE (G)	7.5+3.2	0.75/0.5	4
10	Unweeded control	—	—	—
11	Handweeded control	—	—	—

IPE=Isopropyl ester. BE=Butyl ester. G=granule.
DAT=Days after transplanting.

RESULTS AND DISCUSSION

Infestation of Weeds

The infestation of weeds expressed by the number of weeds per m^2 is presented in Table 2. It was observed that the experimental plots were infested predominantly with broadleaf weeds such as *Monochoria uaginalis* and *Lindernia pyxidaria* while the infestation of grassy and sedge weeds was relatively mild. Table 2 shows that population density of weeds varied considerably among treatments at both weed counts. The treatments of 2,4—D IPE, Benthiocarb, and C—288+2,4—D IPE were infested with smaller number of weeds while the treatments of CP 53619, Benthiocarb +2,4—D IPE, and C—290+2,4—D IPE were more heavily infested with weeds. Among treatments with less weeds, good control of weeds was obtained only by C—288+2,4—D IPE in the second crop of 1971 while adequate control of weeds was apparently available for C—290+2,4—D IPE in the treatments with heavy infestation of weeds in the first crop of 1972 (Chang and Mao, 1972) . The correlation between the average weed control rating in the second corp of 1971 and the average number of weeds per m^2 in the first crop of 1972 gave r value of-0.0389. This value is too small to attain significance, suggesting that weed control effect of herbicide treatments is not related to the degree of weed infestation in the succeeding crop. Thus, residual effect of herbicides on the weed infestation of the following rice crop is not evident in this experiment.

Table 2. Weed infestation in rice field applied with herbicides in the previous crop.

Treatment	Number of weeds per m² at 30 DAT				Number of weeds per m² at 60 DAT				Mean
	Grasses	Broad-leaves	Sedges	Total	Grasses	Broad-leaves	Sedges	Total	
1	45	[illegible]	35	610	75	960	95	1,130	870
2	65	1,430	5	1,500	60	1,330	55	1,445	1,473
3	55	1,005	155	1,215	50	1,060	230	1,340	1,278
4	60	530	80	670	75	835	120	1,030	850
5	90	1,310	70	1,470	90	1,215	115	1,420	1,445
6	25	1,135	30	1,190	25	1,670	125	1,820	1,505
7	10	940	15	965	65	620	55	740	853
8	60	580	15	655	40	1,655	75	1,770	1,213
9	30	1,055	465	1,550	35	1,095	515	1,645	1,598
10	10	1,005	65	1,080	20	1,165	65	1,250	1,165
11	80	410	0	490	70	855	80	1,005	748

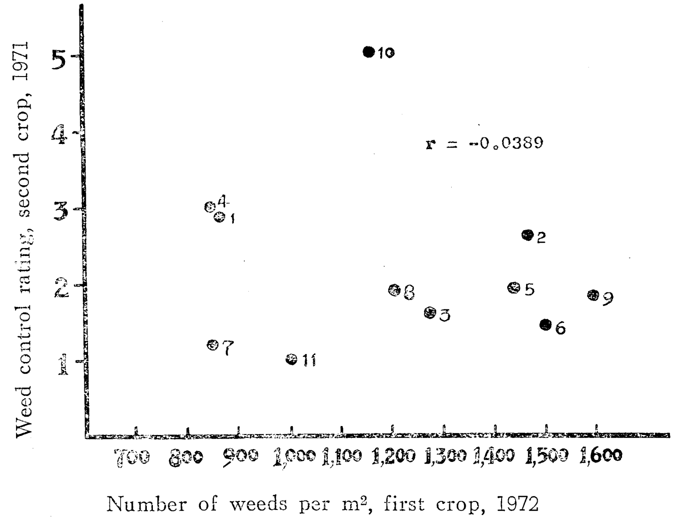

Figure 1. Relationship between average weed control rating in the second crop of 1971 and average number of weeds per m² in the first crop of 1972.

It was of interest, however, to note that the treatment of C—288+2,4—D IPE which showed the best control of weeds in the second crop of 1971 was also infested with less weeds in the first crop of 1972. It was also observed that Handweeded control gave the lowest average number of weeds per m² among 11 herbicide treatments in the first crop of 1972. This seems to indicate that certain herbicide treatments do affect the

infestation of weeds in the following crop although the degree of influence may be different. There will be less seeds produced by weeds for the propagation in the succeeding crop since most of weeds may have been killed before they reach the stage of maturity. Hence, weed population in these particular treatments with good weed control effect may be considerably reduced. It is also possible that application of certain herbicides or herbicide combinations such as C—288+2,4—D IPE at rates necessary to provide satisfactory weed control in transplanted rice may persist in amounts toxic to the growth of weeds in the following crop. Further investigation on this matter appears worthwhile.

Growth Performance of Rice

Plant height and number of tillers at 60 days after transplanting, plant height and number of panicles per hill at maturity stage, number of days from transplanting to heading, and grain yield in kilograms per hectare are shown in Table 3. Toxicity rating was not included because there was practically no trace of rice toxicity and normal growth was apparently available for rice plants in the experimental plots. There was no significant difference among herbicide treatments for plant height and number of tillers per hill recorded at 60 days after transplanting, indicating that early growth of rice plants was not affected by the herbicide treatments of the previous crop. Differences in plant height and number of panicles per hill at maturity stage, days to heading, and grain yield of rice all failed to attain significance, suggesting that growth performance of the adult rice plants in the plots previously applied with herbicides was similar to that of the non-treated ones. The results of this experiment clearly indicate that residues from the application of herbicides in the second crop may not persist in amounts toxic to the growth of rice in the following first crop. The herbicides or herbicide combinations applied in the second crop of 1971 were mostly of experimental materials except CP 53619 (Butachlor) and Benthiocarb which have been on the recommended list of commercial herbicides in Taiwan since 1970 (Lin, 1971).

Table 3. Growth performence of rice in paddy field applied with herbicides in the previous crop.

Treatment	Rice growth at 60 DAT		Rice growth at maturity stage		Days to heading	Grain yield (kg/ha)
	Plant height (cm)	Tillers per hill	Plant height (cm)	Panicles per hill		
1	52.3	13.8	106.8	11.6	97	4,437
2	50.4	13.3	107.7	11.0	99	4,688
3	52.9	13.7	107.0	12.1	98	4,367
4	54.6	13.6	108.8	11.4	99	4,329
5	53.3	13.5	108.6	11.3	100	4,331
6	50.3	13.5	105.0	11.4	98	4,678
7	51.1	11.8	106.9	11.4	99	4,478
8	50.7	12.3	105.1	10.0	98	4,333

9	51.8	12.9	108.2	11.2	99	4,359
10	53.1	13.9	108.8	11.0	99	4,330
11	50.3	12.2	106.7	11.7	98	4,328
LSD 5%	NS*	NS	NS	NS	NS	NS

*Difference not significant at 5% level.

The rice plants of this experiment were grown on the plots which received preemergence application of herbicides on the surface of paddy field in the second crop of 1971. A rapid inactivation of surface-applied herbicides appears likely because herbicides applied on the soil surface are more exposed for the photodecomposition. As soil temperature is an important factor affecting the rate of microbial activity, degradation of herbicides applied in the second crop may be greatly accelerated. In Taiwan, high temperature usually prevails in the second crop of rice. Photodecomposition and microbial decomposition are among factors reported to be associated with the persistence of soil-applied herbicides (Sheets and Danielson, 1960) . These two factors could have been largely responsible for the absence of harmful residual effect of herbicides applied in the second crop, although factors other than these two may also have played a role. This observation is, however, based on the results of only one application and it is doubtful whether continuous usage of herbicides will create a residue problem. It is also not clear that inactivation of herbicides applied in the cool first crop or used in soil-incorporated preplanting application will proceed similarly as that of soil-surface preemergence application of herbicides in the warm second crop. Additional information should be obtained to answer all these questions.

SUMMARY

The residual effects of herbicides applied in the second crop of 1971 on the infestation of weeds and the growth performance of rice in the first crop of 1972 are summarized.

The treatments of 2,4—D IPE, Benthiocarb, and C—288+2,4—D IPE were infested with smaller number of weeds while those of CP 53619, Benthiocarb+2,4—D IPE, and C—290+2,4—D IPE were more heavily infested. However, the correlation between average weed control rating in the second crop of 1971 and average number of weeds per m^2 in the first crop of 1972 gave r value of -0.0389 which was too small to attain significance. This indicates that application of herbicides does not affect appreciably the infestation of weeds in the succeeding crop of rice.

Plant height and number of tillers per hill at 60 days after transplanting, plant height and number of panicles per hill at maturity stage, days to heading, and grain yield per ha did not differ significantly among treatments. Thus, residues from the application of herbicides in the second crop of 1971 may not persist in amounts toxic to the growth of rice in the following first crop of 1972.

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稻田除草劑對後作之殘餘效果

張 萬 來

摘 要

本文係報告民國60年第2期作使用之稻田除草劑對民國61年第1期作水稻之發育及雜草發生之影響。

2,4—D IPE，Benthiocarb 與 C—288+2,4—D IPE 處理之雜草數目較少，而 CP 53619，Benthiocarb+2,4—D IPE與C—290+2,4—D IPE 處理之雜草則較多，惟60年第2期作之平均治草效果級數與61年第1期作之平均雜草數目間之相關係數只有—0.0789，未達顯著水準。由此設論，稻田除草劑之施用並不顯著影響其後期作稻田雜草之發生。

插秧後60日之水稻株高與每株分蘖數，成熟期之水稻株高與每株穗數、抽穗期及每公頃稻谷產量之處理間差異均不顯著。由此可知60年第 2期作施用之稻田除草劑，其在稻田土壤中之遺留量顯然不足影響其後期作水稻之正常發育。

土壤樣本乾燥程度對於磷鉀有效指數的影響[1]

林家棻、李子純、王幼惠[2]

引　言

土壤磷鉀速測之目的，爲瞭解採樣當時田間土壤中所含磷鉀的狀況。由於操作與分析上的方便，土壤速測多採用風乾樣本。但土壤在風乾過程中，因釋放與固定作用之進行，所得磷、鉀有效指數往往與田間實際情形不符。

據 Jackson氏 (12) 稱，田間溼土取回實驗室，經保存一定時間後可減少稀酸之磷抽出量，若屬酸性土壤，風乾後可提高磷抽出量約在10～30%間，烘乾則更倍增之。又施用石灰或多量肥料，樣本乾燥後，往往減少稀酸之磷抽出量。

袁氏 (Yuan) (22) 稱，土壤予以乾燥與溼潤處理，對於添加磷肥之全磷收回率影響不大，但對於各形態磷的收回率則有顯著影響，其中尤以 Fe-P 與 Al-P 之變異最大。

美國 Iowa 大學鑒於乾燥對於土壤營養素有效性之影響，採用土漿法 (Slurry method)，據聞獲得優異成果 (21)。

關於乾燥對於土壤中鉀有效指數之影響，早自1928年 Steenkamp (19) 已發表數據，證明土壤經風乾後，可增加其交換性鉀含量，繼有 Attoe (1) Bray (9) 及 Hanway (11) 等證實之，但 Reitmeir (16) 與Salmon (17) 等氏則認爲若干土壤經風乾後，亦可減少其交換性鉀含量。Jaiyebo (13) 研究 Western Nigeria 土壤時，認爲從該土區土類而言，交換性鉀受風乾的影響不大，但就個別土壤而言，則若干土壤確因風乾而顯著增加或減少其交換性鉀含量，因而利用土壤分析結果，推薦施肥量，此項問題顯得重要。

據 Scott, Hanway 與 Stickney (18) 等氏稱，當土壤中交換性鉀超過一定平衡標準時，在風乾過程中，鉀可發生固定作用，而減低交換性鉀之抽出，但若土壤中交換性鉀低於一定平衡標準時，則風乾可促進鉀之釋放而增加交換性鉀之抽出量。Dowdy 與 Hutcheson氏 (10) 亦同意此說，幷認爲在風乾過程中，鉀之釋放或固定，與土壤中所含粘土礦物之性質有關，伊來石類 (Illite) 可促進鉀之釋放，而蛭石類 (Vermiculite) 與蒙特石類 (Montmorillonite) 則可固定鉀，而後兩者之固定作用與土壤含水量有關。

Bates 與 Scott 研究 (2、3、4、5) 如何以化學方法抑制風乾對於交換性鉀抽出量之影響，其結果認爲烘乾前添加 Dextrose, 可抑制鉀在烘乾過程中的釋放作用，風乾後，若予 Octanol 處理，則可使在風乾過程中所釋出的鉀轉變 (Reverse) 爲非交換性鉀而不被抽出，幷稱若干風乾土壤添加 Octanol 處理之後，雖然未能完全轉變，但所得結果與作物鉀吸收量之相關較用風乾者爲佳。

據 Hanway 與 Scott 氏 (11) 稱，土壤風乾後所增加鉀的抽出量，隨抽出液之種類而異，其順序爲 N NH_4OA_c >0.5N HCI >0.1N HCI>Morgan's 抽出液。

目前本省土壤磷、鉀速測均用風乾樣本，關於乾燥對於土壤磷、鉀有效指數之影響，尙乏資料可供參考。本試驗之目的乃探討：

1.田間溼土經不同乾燥處理之後，對於本省主要土類磷、鉀有效指數之影響，及其與土壤若干性

本文第一作者獲得國家科學委員會半年研究補助費，謹此誌謝。

本研究中所用土壤樣本之採集與分類，諸承陳技正春泉、曾技正浴沂協助與鑑定，土壤中無機形態磷則承張愛華小組分析，謹此深致謝忱。

1. 試驗報告農試字第五八五號　　2. 臺灣省農業試驗所技正、技士、技術員

質之關係。

2.土壤乾燥前後，予以化學處理，對於磷、鉀有效指數變異之控制。

3.土壤樣本經不同乾燥處理後，所得磷、鉀有效指數與稻苗乾重及磷、鉀吸收量之關係。

試 驗 方 法

1.土壤　本試驗中所採用的土壤樣本，計有紅壤、黃壤、安山岩紅壤、鹽土、黑土、看天田土以及冲積土等20種，其性質詳於表 1.。

2.處理　土壤樣本運抵實驗室後，若其水分含量超過40%，立即展開，經一晝夜陰乾後，用 5-mm 篩孔篩別之，否則直接篩別後混勻，作下列處理：

（1）田間溼土　土壤經 5-mm 篩孔篩別後，置於塑膠袋中，予以密閉，不加任何處理，備作分析之用，其樣本所含水分則用 Moisture balance 測定之。

（2）風乾　稱相當於 100gm 乾土的溼土，於一定大小的扁平皿中，置於抽風櫥內，在一定風速下脫水，迨至土壤中水分不變爲止（約4～6天）。

（3）曬乾　將土壤樣本置於人工氣象箱（Growth chamber）中，在日間 80°F 晚間 60°F,日照12小時，光強度 6000～7000 Lux 之下曬乾之，其他同處理（1）。

（4）40°C 烘乾　將土壤樣本置於通風烘箱中，調節溫度 40°C，以48小時烘乾之，其他同處理（1）。

（5）110°C 烘乾　用 110°C 烘乾48小時，其他同處理（4）。

（6）Dextrose-烘乾　處理同（5），但在烘乾前先滴加 Dextrose 液，其用量爲 0.02 moles /10gm 土壤。

表 1. 試 驗 用 土 壤 性 質

Table 1. Some chemical and physical properties of the soils used*

土號 Soil No.	採樣地點 Location	說明 Description	PH	質地 Texture	機械分析 Mechanical analysis Clay %	Silt %	Sand %	陽離與交換能量 C. E. C. meq./100 gm	Exch. K/ C. E. C. %
1	花蓮吉安	片岩冲積土	7.4	SiL	16.76	70.00	13.24	3.50	3.08
4	臺東鎮	片岩冲積土	6.7	SiL	14.76	66.00	19.24	3.88	1.98
6	宜蘭冬山	片岩冲積土	5.1	SiL	14.76	62.00	23.24	6.00	1.28
3	屏東內埔	酸性粘板岩冲積土排水良	4.7	SiCL	34.76	60.00	5.24	8.06	3.75
5	宜蘭五結	酸性粘板岩冲積土排水差	5.1	SiCL	28.76	64.00	7.24	7.00	3.00
18	員林大饒	石灰性粘板岩冲積土有石灰結核	7.6	SiCL	36.76	50.00	13.24	9.00	1.94
19	員林萬平	石灰性粘板岩冲積土無石灰結核	7.6	CL	28.76	50.00	21.24	8.23	2.62
12	臺南舊營	石灰性砂頁岩冲積土	7.5	SiCL	28.76	58.00	13.24	11.13	2.12
14	臺南鹽水	非石灰性砂頁岩冲積土	6.8	SiL	22.76	52.00	25.24	9.81	2.14
17	南投草屯	砂頁岩冲積土	5.5	CL	36.76	42.00	21.24	5.63	6.37
20	基隆汐止	砂頁岩冲積土	5.0	SiCL	34.76	46.00	19.24	8.50	4.40
13	臺南新營	石灰性看天田	6.8	C	40.76	16.00	43.23	17.00	2.96
15	臺南歸仁	非石灰性看天田	6.3	CL	28.76	44.00	27.24	9.69	2.43

16	臺南市安順	鹽土	7.6	SiL	26.76	64.00	9.24	10.56	5.07
2	花蓮玉里	黑土	6.7	SiCL	32.76	48.00	19.24	29.75	1.74
10	臺北新莊	擬黑土	4.8	CL	30.76	34.00	35.24	13.75	2.27
7	桃園楊梅	洪積層母質黃壤	4.5	CL	28.76	50.00	21.24	6.31	4.96
8	新竹東勢	洪積層母質黃壤	5.1	CL	28.76	48.00	23.24	7.13	3.74
9	新竹東勢	洪積層母質紅壤（新水田）	4.7	C	42.76	36.00	21.24	7.13	8.34
11	臺北新莊	安山岩紅壤	4.8	CL	38.76	30.00	31.24	9.75	2.37

* 用風乾土壤測定　Determined with air-dried soils

（7）再溼潤　稱已風乾的土壤於三角瓶中，以每 gm 土壤添加 0.7ml 的水後，加塞，置於人工氣象箱中，經7天後，測定其磷鉀有效指數，所用抽出液濃度則比例增加之。

（8）添加 Octanol　以每 gm 風乾土加 20ml 的 Octanol 置於水溶鍋上，最初24小時，每杯土壤蓋以錶玻璃，其次24小時則取開錶玻璃，蒸乾後測定其磷鉀有效指數。

3.土壤之分析

（1）土壤性質之測定　PH用玻璃電極法(土壤：水＝1：1)，機械分析用浮秤法（Hydrometer method)，陽離子交換能量用醋酸銨法，無機形態磷用 Chang 及 Jackson 與 Peterson 及 Corey 氏之修正法（8、15）。

（2）磷有效指數　用兩種化學分析法：(i) Bray's No.1 method ($0.025N\ HCl-0.03N\ NH_4F$)，但土壤與抽出液之比爲 1:25。(ii) Mehlich method ($0.05N\ HCl-0.025N\ H_2SO_4$)，其土壤與抽出液之比爲 1：10，兩者均用鉬酸銨與 Amino-naphthol-Sulfonic acid 還原劑呈色後，用分光比色計測定之（8）。

（3）鉀有效指數　用兩種化學分析：(i) Mehlich method ($0.05N\ HCl-0.025N\ H_2SO_4$) 及 (ii) 醋酸銨法，後者乃將相當於 5.0gm的乾土置於 100-ml 的離心管中，加上25ml的 IN NH_4OAc (pH 7.0) 液，經搖動 10 分鐘後置於離心機中，在 2,500 rpm 下，轉動5分鐘，將上澄液移於100-ml 量瓶中，然後再加 25ml 醋酸銨液，再搖動10分鐘，離心，傾上澄液於同一量瓶中，連續相同操作4次，最後用醋酸銨液添至標線，用焰光計（Flame photometer）測定之（8）。

（4）Neubauer test 與稻苗中磷、鉀含量之測定　稱乾土 100gm 摻和 50gm 石英砂，置於 11-cm 直徑及高 7cm 之棕色玻璃皿中，加水溼潤，幷添加營養劑，其中測定稻苗磷吸收量時，僅加 15mg 的 N [$(NH_4)_2SO_4$] 及 20mg 的 K_2O (KNO_3)；測定稻苗鉀吸收量時，用 15mg 的 N [$(NH_4)_2SO_4$] 及 7mg 的 P_2O_5 ($NH_4H_2PO_4$)，經拌勻後，將土壤平展於皿底，上舖 150gm 乾石英砂，再添水溼潤後，用分佈均勻的打孔板，將上層溼砂打成91孔，播種前先用鹽水選種 (sp.gr.1.1)，催芽等手續後，將已催芽的臺中65號稻谷播於各孔中，壓實，置於人工氣象室(Growth chamber) 中，調節爲日間溫度 80°F，晚間 70°F, 日照12小時，光度 6000～7000 lux 下，培養2星期，並注意水分管理，取出後，稻苗從砂層表面剪下，經烘乾、稱量、碾細後，取 250mg 乾樣本置於 600°C 高溫電爐中灰化，磷用鉬酸銨與釩酸銨呈色後，用光電比色計測定之；鉀則用焰光計測定之（23）。

結果與討論

1.乾燥對於土壤中磷有效指數之影響　本試驗中設有四種乾燥處理：(i) 風乾(即陰乾)，不受日光作用，(ii) 在人工氣象室內曬乾，以模擬在玻璃室內乾燥者，(iii) 低溫烘乾 40°C 及 (iv) 高溫烘乾（110°C），並以田間溼土作爲對照。各種處理對於土壤中磷有效指數之影響，分別討論如下

(1) Bray's No.1 method 表 2.示風乾對於東北部片岩冲積土（土號1, 4, 6），及北部之紅壤及黃壤中（土號7, 8, 9, 11）磷有效指數之變異不一，或高或低，尤其前者爲然。鹽土（土號16）風乾後，變化不大，其他土壤風乾後，多提高磷有效指數，最高者爲石灰性看天田（土號13）及黑土（土號2），可增加7～8倍，次者爲砂頁岩冲積土（土號 12, 14, 20）及非石灰性看天田（土號15），增加 2～4 倍，其餘多在 1 倍以下。

表 2. 乾燥對於 Bray's 氏磷有效指數之影響

Table 2. Effect of drying on the availability index of soil phosphorus extracted by Bray's No. 1 method (0.025N HCl-0.03N NH_4F)

土 號 Soil No.	田間溼土 Moist soil ppm	風 乾 Air dried soil ppm	曬 乾 Dry in growth chamber ppm	40°c烘乾 Oven dried 40°C ppm	110°c 烘乾 Oven dried 110°C ppm	再 濕 潤 Air-dry rewet ppm	Octanol 處理 Air-dry octanol treated ppm
1	41.3	19.3	25.3	29.9	30.5	25.1	32.0
4	1.4	40.5	30.0	31.9	41.3	9.7	18.4
6	8.2	3.8	3.8	5.0	6.3	2.6	17.0
3	25.5	35.7	20.0	35.0	23.5	7.1	20.7
5	20.7	22.5	23.2	25.3	27.8	18.7	28.8
18	25.0	28.2	26.9	53.2	51.3	28.3	32.5
19	8.2	15.7	9.8	13.8	15.0	8.2	23.7
12	20.0	40.7	36.9	16.3	16.6	16.9	25.0
14	10.0	33.8	17.5	15.7	16.3	6.4	21.3
17	37.5	66.3	57.5	96.8	80.0	45.0	60.0
20	36.9	103.8	86.0	126.9	55.1	35.8	50.3
13	2.5	20.7	16.3	2.5	5.0	2.6	14.5
15	6.3	24.4	13.8	12.5	12.5	5.4	16.9
16	177.5	176.3	187.0	220.0	213.5	182.5	173.8
2	1.9	15.0	9.8	11.3	11.5	1.3	19.0
10	21.3	23.8	31.9	11.3	12.5	6.4	25.7
7	31.9	25.0	36.9	39.8	42.5	13.4	30.5
8	94.5	77.5	93.8	96.3	93.2	43.1	64.0
9	27.2	27.8	38.2	36.7	37.5	15.4	25.0
11	41.9	43.2	38.8	26.3	24.0	12.9	30.5

Mean	32.0	42.2	40.2	45.1	40.8	24.3	36.5
Index	100.0	131.9	125.6	140.9	127.5	75.9	114.1

*表中數字係三次平均而得 Figures in the table are the averages of three replicates.

在人工氣象室內曬乾者，亦有類似趨向，以石灰性看天田及黑土增加最高，達 5 ～ 6 倍，其次爲砂頁岩冲積土及非石灰性看天田，但其增加幅度較風乾者爲低。

用 40°C 及 110° 烘乾者，對於若干土壤有增加磷的釋放作用，土號 5 及16 ，而對於安山岩紅壤（土號11）則有相反趨向。

就20個土壤平均數而言，土壤中磷有效指數，經風乾後可增加32% ，曬乾26%，40°C 烘乾41% 及 110°C 烘乾28%。

（2）Mehlich 氏法 表 3 示除東北部片岩冲積土外，風乾多提高土壤中磷有效指數，但其增加幅度較 Bray 氏法者爲低，鮮有超過 1 倍以上，最高者爲安山岩母質之擬黑土（土號 10）及安山岩紅壤（土號11），達 70%～60 %間，曬乾及 40°C 烘乾者，亦有類似之趨向，但 110°C 烘乾者，顯然提高甚多，尤以無石灰結核之石灰性粘板岩冲積土（土號19）爲然，較田間溼土者增加 3 倍以上。

表 3. 乾燥對於 Mehlich 氏磷有效指數之影響

Table 3. Effect of drying on the availability index of soil phosphorus measured by Mehlich's method (0.05*N* HCl–0.025*N* H_2SO_4)

土 號 Soil No.	田間溼土 Moist soil ppm	風 乾 Air dried soil ppm	曬 乾 Dry in growth chamber ppm	10°C烘乾 Oven dried 40°C ppm	110°C 烘乾 Oven dried 110°C ppm	再 濕 潤 Air-dry rewet ppm	Octanol 處理 Air-dry octanol treated ppm
1	0.4	0.3	2.1	2.0	0.7	0.8	1.0
4	190.0	196.0	235.0	233.0	280.0	206.0	280.0
6	300.0	252.5	267.5	270.0	342.5	400.0	466.0
3	61.0	66.8	74.0	75.0	83.0	67.5	76.0
5	105.3	110.0	110.0	100.0	123.5	105.0	108.5
18	140.0	135.0	137.5	150.0	170.0	160.0	181.0
19	11.0	16.0	14.3	17.9	42.8	27.8	38.0
12	185.0	203.0	205.0	201.0	255.0	222.5	232.0
14	16.1	22.3	17.5	18.3	24.0	14.9	18.0
17	49.8	58.0	57.8	62.0	73.0	53.0	61.5
20	49.8	52.5	52.5	56.5	57.8	43.8	43.5
13	17.4	25.3	19.4	20.0	26.5	19.2	22.0
15	26.0	32.5	28.3	27.5	34.0	24.3	28.8
16	480.0	530.0	503.0	509.0	635.0	535.0	535.0

2	21.3	25.3	24.5	27.0	38.0	31.0	33.0
10	7.3	12.5	10.0	10.0	12.0	6.5	9.5
7	16.6	22.0	19.6	19.1	22.0	13.5	22.6
8	59.8	67.5	61.8	65.5	64.5	53.2	61.5
9	13.0	17.3	16.5	17.0	17.0	12.8	16.5
11	10.0	16.0	13.5	13.5	19.0	10.0	12.6
Mean	88.0	93.0	93.5	94.2	116.0	100.3	112.4
Index	100.0	105.7	106.2	107.1	131.0	114.0	127.7

*表中數字係由三次平均而得 Figures in the Table are the averages of three replicates.

就20個土壤之平均數而言，風乾、曬乾或 40°C 烘乾較田間溼土所得磷有效指數約增加 5 %～7 %，但 110°C 烘乾則可增加32%。

綜上而言，乾燥對於土壤磷有效指數之變異，除視個別土壤性質外，尙受所用抽出液種類的影響甚大。

2.乾燥對於土壤中無機形態磷之變異 由上節可知，乾燥對於土壤磷有效指數之變異，亦受抽出液種類的影響。 Bray 氏第一法以抽取 Al—P 及 Fe—P 爲主， Ca—P 爲副，因此凡土壤中所含 Al—P 及 Fe—P 高於 Ca—P 時，Bray 氏法所得磷有效指數高於 Mehlich 氏者，如土號 7.8.9.10.11，而 Mehlich 氏法則以抽取 Ca—P 爲主，Fe—P 爲副，因此凡土壤中含 Ca—P 高於 Fe—P 或 Al—P 者，則以 Mehlich 氏法所得磷有效指數大於 Bray 氏法者，其中唯一例外爲土號 1，可能因風化程度較弱， Ca—P 不易抽出所致。

表 4 乾燥對於土壤中無機形態磷百分比分佈之影響

Table 4. Effect of drying on the percentage distribution of inorganic forms of soil phosphorus

土 號 Soil No.	風乾 Air dry, ppm			烘乾 Oven dry, ppm			增加或減少 % Increase or decrease, %		
	Al—P	Fe—P	Ca—P	Al—P	Fe—P	Ca—P	Al—P	Fe—P	Ca—P
1	36.3	7.6	1316.0	47.6	11.8	1286.0	131.1	155.3	97.7
4	15.4	46.5	880.0	21.7	47.5	140.9	140.9	102.2	92.7
6	18.0	126.6	2234.0	20.8	124.0	2064.0	115.6	98.0	92.4
3	21.4	172.2	272.0	35.4	153.2	260.0	165.4	89.0	95.6
5	45.5	272.0	362.0	61.5	285.0	374.0	135.2	104.8	92.7
18	51.7	204.2	791.0	52.2	186.0	796.0	101.0	91.1	100.6
19	29.8	50.9	870.0	33.0	53.8	880.0	110.7	105.7	101.2

12	26.3	60.0	677.0	29.4	114.0	666.0	111.8	190.0	98.4
14	22.0	164.0	97.0	22.4	88.1	85.8	101.8	53.7	88.5
17	129.2	375.0	104.1	136.0	345.0	102.0	105.3	92.0	98.0
20	160.8	192.0	54.7	160.8	178.4	54.5	100.0	92.9	99.6
13	12.2	112.8	96.9	16.4	115.4	106.0	134.4	102.3	109.4
15	14.8	149.6	134.1	15.9	86.3	132.1	107.4	57.7	98.5
16	172.0	418.0	1060.0	204.0	360.0	1126.0	118.6	86.1	106.2
2	16.8	54.4	212.0	30.3	76.6	209.0	180.4	140.8	98.1
10	190.8	480.0	68.8	162.0	520.0	83.6	84.9	108.3	121.5
7	49.3	153.6	46.5	54.9	151.6	42.4	111.4	98.7	91.2
8	156.1	264.0	71.4	157.2	250.0	74.2	100.7	94.7	103.9
9	84.0	528.0	69.7	88.1	353.0	64.4	104.9	66.9	92.4
11	238.0	874.0	115.0	430.5	875.0	107.3	180.9	100.1	93.3
Mean	74.5	235.3	476.6	89.0	218.7	466.4	122.1	101.5	98.6

*風乾乃指土壤樣本置於溫室內風乾者，烘乾乃指在 110°C 烘箱烘乾48小時

Soil Samples for air dry were conducted in greenhouse as conventional method, and for oven-dry were dried in oven at 110°C for 48 hours.

表中數字乃由二次平均而得　　Figures in the Table are the means of two replicates.

Bray's 磷有效指數受乾燥之影響較 Mehlich 氏爲大，其中緣由必與土壤中無機形態磷之轉變有關。表4. 示片岩冲積土（土號1, 4, 6），石灰性粘板岩冲積土（土號18.19），鹽土（土號16）及玉里黑土（土號2）均以 Ca—P 爲主，酸性粘板岩冲積土（土號 3, 5），石灰性砂頁岩冲積土（土號12, 14）以及看天田（土號 13, 15）則以 Ca—P, Fe—P 爲主，而酸性砂頁岩冲積土（土號 17, 20），北新莊安山岩母質之擬黑土及紅壤（土號 10, 11），以及洪積層之紅壤及黃壤（土號 7, 8, 9）均以 Al—P 及 Fe—P 爲主，經 110°C 烘乾後，對於各形態磷間相對多寡之變異不大，但對於 Al—P 與 Fe—P 之變異則甚大，其中除土號10外， Al—P 經烘乾後均普遍提高，其中增加達 80%者，有土號2及11，其次爲土號3，再次爲土號1, 4, 5, 13，不增加者有土號8, 14, 18, 20；而 Fe—P 則增減互見，減少最多者爲土號14, 15，而增加最多者則爲土號12，增減不顯明者有土號 4, 6, 7, 11。Ca—P 之變異不大，除土號10及14外，其變異多在10%以下，由此可知土壤中Al—P與Fe—P受乾燥之影響甚大，而 Bray's No.1 method 以抽取 Al—P 及 Fe—P爲主，因此土壤中磷以 Bray 法測定，作施肥推荐時，對於土壤樣本之處理，值得特別注意。

3.乾燥對於土壤中鉀有效指數之影響　與測磷時相同，亦設有4處理，即 (i) 風乾，(ii) 曬乾，(iii) 40°C 烘乾及 (iv) 110°C 烘乾，亦以田間溼土作爲對照。各處理對於鉀有效指數之影響，討論於次：

（1）醋酸銨法　表 5. 示田間溼土經風乾後多提高其鉀有效指數，其中增加最多者爲北新莊安山岩母質之擬黑土（土號10）及臺東片岩冲積土（土號4），其次爲非石灰性看天田土（土號13），再次爲石灰性砂頁岩冲積土（土號12），石灰性看天田土（土號13），安山岩母質紅壤（土號11），

及玉里黑土（土號２），其他土壤增加幅度較低。曬乾與風乾所得趨向相似，但經烘乾處理後，可呈現三種情形：（ｉ）隨乾燥溫度提高而增加土壤鉀之固定作用，使所得鉀有效指數低於田間溼土者，如片岩冲積土（土號1、6）及酸性粘板岩冲積土（土號３）。(ii)隨溫度提高而增加鉀之釋放作用者爲看天田土（土號13、15），石灰性砂頁岩冲積土（土號12、14）及黑土（土號２）。(iii) 不受乾燥溫度顯明影響者爲洪積層之紅壤或黃壤（土號７、８、９），及酸性砂頁岩冲積土（土號17、20）。由此可知土壤中鉀之固定或釋放，受溫度之影響至鉅。就20個土壤總平均數而言，鉀有效指數可因風乾提高16%，曬乾18%， 40°C 烘乾16%，而 110°C 烘乾則爲30%。

表 5. 乾燥對於醋酸銨—鉀有效指數之變異

Table 5. Effect of drying on the availability index of soil potassium measured by ammonium acetate method (1*N*,pH 7.0)

土號 Soil No.	田間濕土 Moist soil ppm	風乾 Air-dry soil ppm	曬乾 Dry in growth chamber ppm	40°C 烘乾 oven dried 40°C ppm	110°C 烘乾 oven dried 110°C ppm	烘前加 Dextrose Dry at 110°C with dextrose ppm	再溼潤 Air-dry rewet ppm	Octanol處理 Air-dry Octanol treated ppm
1	100.0	98.0	84.0	74.0	78.0	90.0	66.0	54.0
4	31.0	51.0	51.0	56.0	46.0	26.0	34.0	21.0
6	46.0	52.0	46.0	34.0	30.0	52.0	46.0	30.0
3	214.0	233.0	220.0	156.0	124.0	248.0	176.0	101.0
5	92.0	93.0	95.0	82.0	86.0	76.0	86.0	66.0
18	66.0	70.0	62.0	66.0	84.0	74.0	58.0	48.0
19	90.0	94.0	82.0	86.0	82.0	112.0	82.0	62.0
12	78.0	98.0	110.0	104.0	178.0	74.0	95.0	64.0
14	60.0	70.0	78.0	82.0	114.0	66.0	76.0	60.0
17	130.0	150.0	151.0	153.0	150.0	138.0	132.0	134.0
20	118.0	142.0	150.0	142.0	142.0	130.0	138.0	130.0
13	118.0	150.0	170.0	198.0	286.0	110.0	148.0	102.0
15	58.0	86.0	94.0	116.0	144.0	64.0	88.0	64.0
16	218.0	226.0	224.0	178.0	254.0	230.0	228.0	237.0
2	167.0	220.0	245.0	270.0	312.0	180.0	210.0	146.0
10	54.0	102.0	108.0	118.0	114.0	94.0	102.0	92.0
7	118.0	126.0	123.0	123.0	126.0	130.0	122.0	110.0
8	87.0	96.0	102.0	106.0	102.0	110.0	87.0	94.0
9	230.0	238.0	236.0	246.0	234.0	214.0	244.0	204.0
11	64.0	82.0	90.0	102.0	100.0	86.0	82.0	86.0

Mean	107.0	123.9	126.1	124.6	139.3	115.2	115.0	95.3
Index	100.0	115.8	117.9	116.4	130.0	107.7	107.5	89.3

*表中數字係由三次平均而得 Figures in the Table are the means of three replicates.

（2）Mehlich 氏法　表6示田間溼土經乾燥後，用 Mehlich 氏法所得鉀有效指數之變異情形，與用醋酸銨法測定者，極爲接近，風後乾鉀有效指數亦普遍提高，而片岩冲積土（土號1、6）及酸性粘板岩冲積土（土號3）之鉀有效指數，仍隨乾燥溫度提高而降低，其他土壤多隨溫度提高而增加，其中最明顯者，仍爲看天田土（土號13、15）及黑土（土號2）。就20個土壤總平均數而言，風乾或曬乾增加鉀有效指數在28%～29%間，40°C 烘乾增加34%，而 110°C 烘乾則高50%，其變異幅度較醋酸銨法者爲大。蓋 Mehlich 法之抽出液係由 HCl 及 H_2SO_4 配製而成，兩者均屬强酸，活性强，因而其取代能力則較醋酸銨弱，所得鉀有效指數亦低，但變異幅度以百分比表示時，則較醋酸法大。

表6　乾燥對於 Mehlich 氏鉀有效指數之影響

Table 6. Effect of drying on the availability index of soil potassium measured by Mehlich's method (0.05N HCl-0.025N H_2SO_4)

土號 Soil No.	田間溼土 Moist soil ppm	風乾 Air-dry soil ppm	曬乾 Dry in growth chamber ppm	40°C 烘乾 Oven-dry 40°C ppm	110° 烘乾 Oven-dry 110°C ppm	烘前加 Dextrose Dry at 110°C with dextrose ppm	再濕潤 Air-dry rewet ppm	Octanol處理 Air-dry Octanol treated ppm
1	35.0	35.0	25.5	24.0	26.0	43.0	34.0	22.5
4	13.0	15.0	15.0	15.0	17.0	21.0	19.0	15.0
6	20.0	25.0	21.0	19.0	17.0	21.0	23.0	18.0
3	78.0	104.0	99.0	64.5	56.0	102.0	83.0	57.0
5	37.0	40.5	39.0	39.0	43.5	33.0	41.0	34.5
18	27.0	29.0	27.0	33.0	37.0	31.0	27.0	19.0
19	35.0	41.0	39.0	41.0	43.0	47.0	37.0	29.0
12	37.0	50.0	49.0	61.0	73.5	31.0	41.0	29.0
14	23.0	32.0	29.0	35.0	54.0	33.0	29.0	19.0
17	50.0	59.0	59.0	67.0	67.0	53.0	55.0	53.5
20	43.0	55.0	57.0	63.5	61.0	39.0	55.0	45.0
13	35.0	57.0	59.0	69.0	107.0	37.0	43.0	29.0
15	27.0	42.0	39.0	49.0	71.0	33.0	33.0	23.5
16	89.0	116.0	113.0	119.0	129.0	111.0	101.0	87.0
2	47.0	67.0	77.0	93.0	106.5	63.5	66.0	63.0
10	23.0	31.0	29.0	25.0	33.0	24.0	27.5	22.0

7	38.0	49.0	54.5	55.5	55.0	55.0	48.0	45.0
8	26.0	39.0	47.0	43.5	45.0	41.0	35.0	37.0
9	75.0	93.0	97.5	99.0	95.0	77.0	81.0	73.5
11	19.0	26.5	23.0	28.0	29.0	13.0	22.0	22.0
Mean	38.9	50.3	49.9	52.2	58.3	45.4	45.0	37.2
Index	100.0	129.3	128.3	134.2	149.9	116.4	115.7	95.6

*表中數字係由三次平均而得 Figures in the Table are the means of three replicates.

綜上而言，鉀之釋放作用受溫度之影響甚大。過去本省土壤速測對於樣本乾燥都無嚴格規定，因而所得鉀有效指數有時偏高，有時偏低，視當時乾燥溫度而定，今後須加注意。

4.土壤性質與磷、鉀有效指數因乾燥而變異之關係　本試驗中所用20個土壤樣本，各有其代表性，且所用之樣本均屬表土，受長期管理之影響甚大，因而單從土類窺探其乾燥對於磷鉀有效指數之變異，誠屬不易。茲以田間濕土所得磷、鉀有效指數各作爲 100 ，求風乾或 110°C 烘乾之百分比，用以表示磷、鉀有效指數之變異情形，然後再以百分比，與土壤性質測定値分別求其相關係數，如表 7 及 8 。

表 7 示在 Bray 氏法中，風乾對於磷有效指數之變異與土壤 pH, Clay, C.E.C 以及各形態磷之相關係數，均未達到顯著平準，但與 Clay 及 Al—P 及Fe—P均爲負相關，且接近顯著平準；烘乾則不然，其變異與土壤 C.E.C 之相關係數達到極顯著平準，而與 Al—P 及 Fe—P 均爲負相關。據 Baryosef 氏(6)稱，高嶺土類懸液經烘乾後，土粒表面負電荷之增加較風乾者大，由於負電荷增加，相對地表面正電荷將減少，而增加磷之釋出。本試驗中， Bray 氏磷有效指數之變異與 C.E.C 達到顯著關係，似與土粒表面電荷之變遷有關。此外，不論風乾或烘乾，磷有效指數之變異，均與 Al—P 及 Fe—P 爲負相關。可能因 Bray 氏法中以測定 Al—P 及 Fe—P 爲主，而該兩形態磷變異受乾燥之影響最大所致。

表 7　土壤性質與磷有效指數因乾燥而變異之關係

Table 7. Relationships of some soil properties to the change of availability index of soil phosphorus as affected by drying

有效指數 Availability index as affected by	相關係數 Correlation coefficient					
	pH	Clay	C. E. C.	Al-P	Fe-P	Ca-P
土壤磷用 Bray 法測定　Soil P as measured by Bray's No. 1 method						
風乾 Air drying	0.1811	−0.3224	0.0515	−0.3090	−0.3105	0.0426
烘乾 Oven drying	0.2952	0.0072	0.6839**	−0.3618	−0.3514	0.2310
土壤磷用 Mehlich 法測定　Soil P as measured by Mehlich's method						
風乾 Air drying	−0.2556	0.4975*	0.3381	0.3796	0.5260*	−0.6285**
烘乾 Oven drying	0.3563	0.0028	0.1110	−0.0813	−0.0982	0.0913

表 8　土壤性質與鉀有效指數因乾燥而變異之關係

Table 8. Relationships of some soil properties to the change of availability index of soil potassium as affected by drying

有效指數 Availability Index as affected by	相關係數 Correlation coefficient			
	pH	Clay	C. E. C.	Exch.K/C.E.C.x 100
土壤鉀用醋酸銨法測定 Soil K as measured by Ammonium acetate				
風乾 Air drying	−0.0927	−0.0934	0.2800	−0.1904
烘乾 Oven drying	0.2776	0.1900	0.5400*	−0.3410
土壤鉀用 Mehlich 法測定 Soil K as measured ay Mehlich's method				
風乾 Air drying	−0.1374	0.3182	0.5235*	0.1154
烘乾 Oven drying	0.2813	0.2748	0.5899**	−0.2077

在 Mehlich 氏法中，風乾對於磷有效指數之變異與粘土含量， Fe—P 及 Ca—P 均有顯著關係，但與 Ca—P 則爲極顯著之負相關，此似與 Mehlich 氏以測定 Ca—P 爲主有關，但烘乾後，磷有效指數之變異與上述土壤性質之關係則均不明顯。

由上述兩測定法中，風乾或烘乾所得磷有效指數之變異與土壤性質之關係多不一致，此可能兩者對於土壤脫水快慢，以及脫水程度差異甚大，因而對於土壤膠體吸着性能Isomorphons replacement，土壤表面電荷密度，以及 pH 產生不同的影響，而土壤中磷之固定與釋放，與此等因子則有莫大的關係所致(7)。

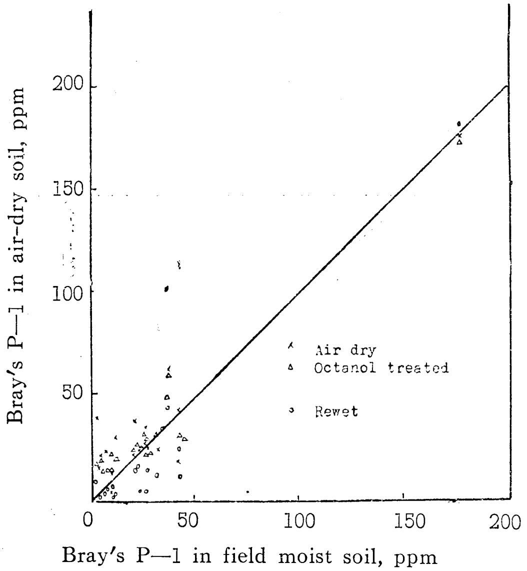

Fig. 1. Comparison of Bray's P in air-dry, air-dry rewet, and air-dry octanol-treated soil with that in field moist soil

表 8 示土壤中鉀有效指數之變異 ， 與土壤 C.E.C 均爲正相關，且多數達到顯著或極顯著平準。換言之，土壤 C.E.C 愈大者，乾燥後釋出之鉀亦愈多，但本省農田土壤之 C.E.C 多在 20meq/100gm 以下，因此在後節討論土壤鉀與稻苗乾重或 K 吸收量相關時，土壤 K 有效指數之變異，受乾燥影響不若土壤磷之大。

5 添加化學藥品或再濕潤對於磷、鉀有效指數之影響　由上所述 ， 可知土壤樣本經乾燥後 ， 對於磷 、 鉀有效指數之變異甚大 ， 若依照 Bates 氏 (2.3.4.5) 等所述 ， 在土壤樣本乾燥前後，添加化學藥品，可予以抑制，則不失爲解決途徑之一。茲以表 2 中田間濕土所得 Bray 氏法磷有效指數作爲橫座標，風乾所得者，作爲縱座標，然後將再濕潤 (Air-dry rewet) 及 Octanol 處理 (Air-dry octanal treated)分別繪於圖 1，圖中對角線表示磷有效指數不因乾燥

而變異，凡點高於該對角線者表示磷因乾燥或其他處理之釋放作用而增加，低於對角線者則因固定而減少。圖中顯示再濕潤後，所得磷有效指數多低於對角線，Octanol 處理者比較接近對角線，風乾者，多在對角線之上，若干點且遠離對角線，由此顯示再濕潤（Rewet） 或 Octanol 處理，對於磷因乾燥而釋放，確有抑制作用，但無法將個別土壤之磷有效指數完全恢復至田間濕土情形者，但是否可以改進土壤磷有效指數測定值與作物磷吸收量之關係 ， 容另節討論之 。 Mehlich 氏法所得結果與 Bray 氏法者相似，由於前者不適用於稻田，不予贅述。

同樣地利用表 4 資料，將田間濕土所得鉀有效指數作橫座標，風乾所得者，作縱座標，然後將再溼潤及 Octanol 處理繪於圖 2 ；另將烘乾及烘乾前加 Dextrose ，繪於圖 3 ，圖中各以對角線作標準，凡點高於對角線者，表示因乾燥或其他處理而釋放，低於對角線者，則表示固定。圖 2 示土壤經風乾後所得鉀有效指數多在對角線之上，再濕潤處理者亦然 ， 但有若干點則分佈在對角線之下 ， 用 Octanol 處理者，所得鉀有效指數，多在對角線之下。換言之， Octanol 處理者，對於鉀之固定作用較再濕潤處理者為强。

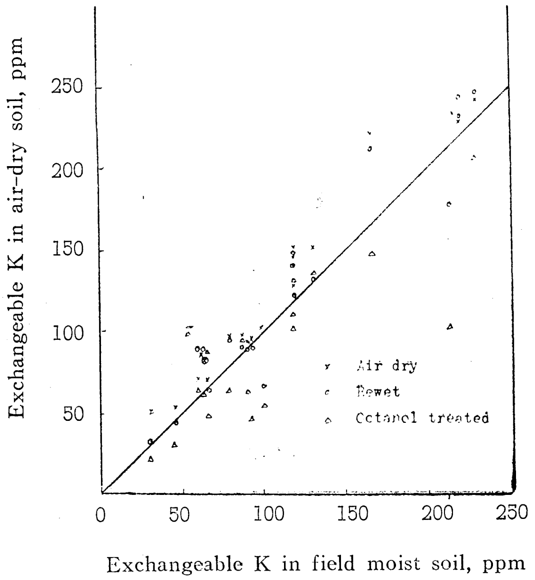

Fig.2. Comparison of the exchangeable K in air-dry, air-dry rewet, and air-dry octanol treated soil with that in field moist soil

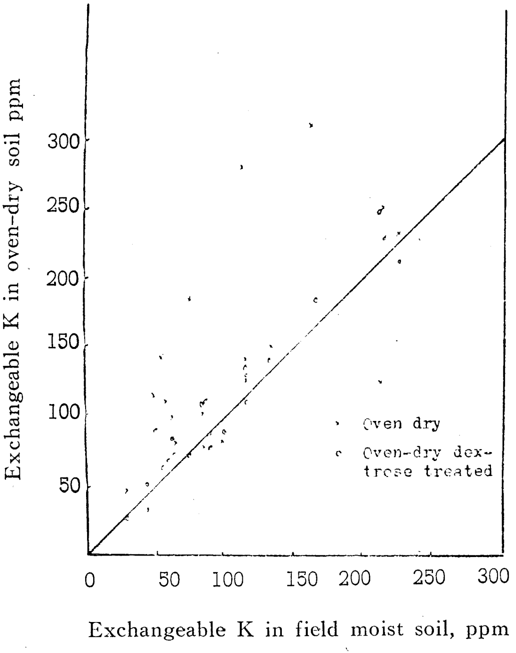

Fig.3. Comparison of the exchangeable K in oven-dry and oven-dry dextrose treated soil with that in field moist soil

圖 3 示土壤經 110°C 烘乾後，所得鉀有效指數，多遠高於對角線，但經 Dextrose 處理後，其點之分佈則多接近於對角線，顯示 Dextrose 對於抑制鉀之釋放確有功效，尤其對於砂頁岩沖積土（土號12、14、17、20）、看天田土（土號13、15）、鹽土（土號16）及黑土（土號 2 ）等最為顯著（參看表4.），但對其他土壤則未必盡然。此外，土壤粘重者添加 Dextrose 烘乾後，結塊堅固，處理費時，且抽出之濾液呈褐色，用焰光計法測定固無大礙，但噴頭易被阻塞，若用其他比色法則感不便，值得注意。

Mehlich 氏法所得結果與醋酸銨法相似，不予論列。

綜上而言，添加化學藥品或再濕潤對於土壤磷、鉀因乾燥釋放或固定，確有相當抑制功效，但仍無法將個別土壤完全恢復至如田間濕土情形。

6.不同乾燥處理所得磷、鉀有效指數與稻苗乾重及磷、鉀吸收量之關係。 以土壤速測供施肥推薦量之參考時，其測定值必須與作物收量或要素吸收量間，獲致良好的關係，否則土壤速測值之意義不大。因此田間濕土，經不同乾燥處理後，所得磷、鉀有效指數之變異，是否可影響其對於作物收量或要素吸收量之關係，以 Neubauer 法檢定結果，示於表9及10中。

表9.示用 Bray 法測定時，14 個土壤（鈣質土壤除外）所得相關係數中，以田間濕土所得磷有效指數與稻苗乾重及磷吸收量之相關最高，且達極顯著平準，其次爲再濕潤與 Octanol 處理者，其相關係數亦達顯著平準，其他乾燥處理與稻苗乾重之相關均不顯著；與磷吸收量則均達到顯著平準，但其相關係數仍較再濕潤或 Octanol 處理者爲低。由此顯示用 Bray 氏法速測時，以田間濕土所得結果最佳，否則以風乾土壤加以水再濕潤，或以 Octanol 處理，均有相當改進功效。

表9. 土壤樣本經不同乾燥處理後所得磷有效指數與稻苗乾重與磷吸收量之相關

Table 9. Correlations between soil P values determined with samples prepared in different dryings and the dry matter content/P–uptake of rice seedlings from Neubauer test

磷測定所用之土壤樣本 Soil samples used for P determination	相關係數 Coefficients of determination γ ylogx			
	14 Soils*		20 Soils**	
	稻苗乾重 Dry matter content	磷吸收量 P–uptake	稻苗乾重 Dry matter Content	磷吸收量 P–uptake
土壤中磷用 Bray 氏法測定 Soil P determined by Bray's No. 1 method				
田間濕土 Field moist soil	0.8560**	0.9046**	0.5586*	0.7545**
風　乾 Air-dry soil	0.3114	0.5029	0.1501	0.5200*
晒　乾 Dry in growth chamber	0.5304	0.6760**	0.2924	0.6306**
40°C 烘乾 Oven dry at 40°C	0.4897	0.6600*	0.3984	0.6716**
110°C 烘乾 Oven dry at 110°C	0.4945	0.6622**	0.3605	0.6648**
再濕潤 Air-dry rewet	0.6049*	0.7472**	0.2834	0.5843**
Octanol 處理 Air-dry octanol treated	0.5809*	0.8050**	0.2628	0.6755**
土壤中磷用 Mehlich 氏法測定 Soil P determined by Mehlich's method				
田間濕土 Field moist soil	−0.0623	0.0032	−0.2001	0.1160
風　乾 Air-dry soil	−0.0561	0.1115	−0.1900	0.1098
晒　乾 Dry in growth chamber	−0.0548	0.0716	−0.1819	0.0947
40°C 烘乾 Oven dry at 40°C	−0.0555	0.0378	−0.1893	0.0947
110°C 烘乾 Oven dry at 110°C	−0.1354	0.1230	−0.2466	0.0285
再濕潤 Air-dry rewet	−0.1026	0.0914	−0.2343	0.0172
Octanol 處理 Air-dry octanol treated	−0.1184	0.1162	−0.2342	0.0204

* 不包括鈣質土壤在內　Excluding calcareous soils　　* 5% 顯著平準　Significant at 5%

** 包括所有試驗土壤　Including all soils used in the test.　　** 1% 顯著平準　Significant at 1%

就20個土壤樣本而言，稻苗乾重僅與田間濕土所得磷有效指數獲得顯著相關，與其他乾燥處理所得者均不顯著，而稻苗磷吸收量則與各處理間均獲得顯著相關，但仍以田間濕土所得者最高。在此值得注意者，爲14個土壤所得之相關係數多高於20個所得者，此可能如 Syers et. al. (20)等氏所述鈣質土壤含有遊離鈣鹽，可中和部分或全部 Bray's No.1 法抽出液中之酸，并可與 NH_4F 中之 F^- 離子形成 CaF_2，在抽出過程中再吸着磷，因此所得測定值，多不能代表土壤中存在之磷而減低其相關係數。本省鈣質土壤磷之速測法，亟須作進一步之研究。

Mehlich氏法所得磷有效指數與稻苗乾重或磷吸收量之相關係數均不顯著，可能稻苗對於 Ca—P 不感興趣，而 Mehlich 氏法所抽出之磷，卻以 Ca—P 爲主所致。

表10. 示在醋酸銨法中，土壤經不同乾燥處理後，所得鉀有效指數與稻苗乾重或鉀吸收量均有極顯著之正相關，但相關係數中，多以田間濕土所得者較乾燥處理者爲低，其中尤以 110°C 烘乾所得之相關係數多居高位。烘乾前加 Dextrose，或風乾後再濕潤，或以 Octanol 處理，對於相關情形之改進並無顯明效果。

表10. 土壤樣本經不同乾燥後所得鉀有效指數與稻苗乾重與鉀吸收量之相關

Table 10. Correlations between soil K values determined with samples prepared in different dryings and the dry matter content/K-uptake of rice seedlings from Neubauer test

鉀測定所用之樣本 Soil samples used for K determination	相關係數 Coefficients of determination r_{ylogx}			
	14 soils*		20 soils**	
	稻苗乾重 Dry matter content	鉀吸收量 K-uptake	稻苗乾重 Dry matter content	鉀吸收量 K-uptake
土壤中鉀用醋酸銨法測定 Soil K as determined by Ammonium Acetate				
田間濕土 Field moist soil	0.6947**	0.7614**	0.6309**	0.8169**
風乾 Air-dry soil	0.7999**	0.7764**	0.6860**	0.7507**
晒乾 Dry in growth chamber	0.8533**	0.8068**	0.7172**	0.7805**
40°C 烘乾 Oven dry at 40°C	0.8229**	0.7916**	0.6760**	0.7431**
110°C 烘乾 Oven dry at 110°C	0.8844**	0.8827**	0.6859**	0.8132**
烘乾前加 Dextrose Oven-dry dextrose treated	0.7279**	0.7098**	0.6698**	0.6574**
再濕潤 Air-dry rewet	0.8231**	0.8357**	0.7381**	0.8061**
Octanol 處理 Air-dry octanol treated	0.7632**	0.7543**	0.7260**	0.7732**
土壤中鉀用 Mehlich 氏法測定 Soil K as determined by Mehlich's method				
田間濕土 Field moist soil	0.6667**	0.7405**	0.6085**	0.7145**
風乾 Air-dry soil	0.3738	0.6281*	0.3892	0.6959**
晒乾 Dry in growth chamber	0.7283**	0.8113**	0.6987**	0.7989**
40°C 烘乾 Oven dry at 40°C	0.7491**	0.8926**	0.7105**	0.8391**
110°C 烘乾 Oven dry at 11°C	0.8152**	0.9409**	0.6933**	0.8607**
烘乾前加 Dextrose Oven-dry dextrose-treated	0.3522	0.6800**	0.3616	0.4975*
再濕潤 Air-dry rewet	0.7226**	0.7926**	0.6798**	0.7832**
Octanol 處理 Air-dry octanol-treated	0.6730**	0.7423**	0.6330	0.8483**

* 5%顯著平準 Significant at 0.05 level; ** 1%顯著平準 Significant at 0.01 level

＋ 不包括鈣質土壤 Excluding calcareous soils, ＋＋包括本試驗所有土壤 Including all soils used.

在 Mehlich 氏法中，田間濕土所得鉀有效指數與稻苗乾重或鉀吸收量之相關係數亦達到極顯著平準，但仍低於 110°C 烘乾者。烘乾前加 Dextrose 所得相關係數均低於田間濕土，且有未達顯著平準者。風乾後加水再濕潤，或以 Octanol 處理，所得相關係數仍低於烘乾處理者，對於相關之改進亦無顯明的效果。

綜上而言， 110°C 烘乾處理者，所得鉀有效指數與稻苗乾重或鉀吸收量之相關係數多高於田間濕土者，此可能在 Neubauer 法中僅用 100gm 的土壤，而播91粒的稻種，經２星期後稻根密佈於土粒間，在 Intensive 吸收情形之下，田間濕土所得鉀有效指數可能偏低 ，烘乾後鉀有效指數提高，因而增加 Capacity factor 之估計範圍，使相關係數提高。但在田間情形之下 ， 其結果如何，仍待證實。總之，土壤中鉀之釋放或固定，與乾燥溫度之影響甚大，因此土壤速測樣本之乾燥條件應予一致，否則對於相關係數即使不受影響，但對於鉀肥之推薦則有很大偏差。

摘要與結論

本文之目的乃探討土壤樣本乾燥後，對於磷、鉀有效指數之影響，與土壤性質、作物收量以及磷、鉀吸收量之關係；同時并探討其抑制方法。經選用20種本省主要土壤之樣本，予以不同乾燥處理後，分別用兩種磷、鉀速測法加以測定，所得結果摘要如下：

（１）田間濕土經乾燥後，磷有效指數因個別土壤而變異，或增或減，相差甚大。在 Bray 氏法中平均較田間濕土增加25%～40%，其變異幅度與土壤之 C.E.C 大小有關。在 Mehlich 氏法中磷有效指數之變異幅度較 Bray 氏法爲低，可能因土壤中 Al—P及Fe—P 受烘乾之後，變異甚大，而 Ca—P 則較小所致。就平均數而言，風乾、曬乾或 40°C 烘乾約較田間濕土增加 5%～7 %，但 110°C 烘乾者可提高至32%，其變異幅度與粘土，Fe—P, 及 Ca—P 等含量有關。

（２）田間濕土經乾燥之後，鉀有效指數普遍提高。在醋酸銨法中，平均較田間濕土增加15%～17%，烘乾者可達30%，而在 Mehlich 氏法中則可提高至28%～34%，110°C 烘乾者可達49%，其變異情形與土壤之 C.E.C 成顯著之正相關。

（３）烘乾前加 Dextrose, 或風乾後加水濕潤，或施以 Octanol 處理，確可抑制磷、鉀因乾燥而釋放，但無法將個別土壤完全恢復至與田間濕土一致。

（４）利用 Neubuaer 法檢定土壤，經不同乾燥處理後 ， 所得磷、 鉀有效指數與稻苗乾重或磷、鉀吸收量之相關情形，顯示 Mehlich 氏法不適於稻田速測之用， Bray—P 所得之相關係數，以田間濕土最高，且達極顯著平準，其次爲再濕潤處理或 Octanol 處理，亦達顯著或極顯著平準；風乾、曬乾或烘乾處理者最低，甚至有未達顯著平準。但 Bray 法應用於鈣質土壤時，其相關係數有減低趨勢。Mehlich—K 及醋酸銨 —K之相關係數均達極顯著平準，烘乾者其相關係數較田間濕土者有更高之趨勢，此可能因爲烘乾可提高鉀有效指數之測定值。而在Neubauer 法栽培之下，所用土壤有限，但播種量高，其相關係數受土壤中鉀量 (Quantity) 之影響較鉀強度 (Intansity) 爲大。

因此就土壤速測值與作物收量或 PK 吸收量之相關而言，樣本乾燥對於土壤中 Al—P 及 Fe—P 變異甚大，利用 Bray′s 法測定時，以田間濕土爲宜，對於 Mehlich—K 及醋酸銨—K之影響雖然較小，但因 K 之釋放受乾燥溫度之影響甚大，樣本乾燥條件必須一致，否則將影響推薦量估計之偏差。

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EFFECT OF DRYING ON THE AVAILABILITY INDEX OF SOIL PHOSPHORUS AND POTASSIUM

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Yu-hwea, Wong

Summary

The aim of this study was to find out the effect of drying on the soil PK and its relation to dry matter content as well as PK-uptake of rice seedlings. The control of PK-releasel/fixation on drying by addition of chemicals was also involved.

Twenty soil samples including 8 main soil groups of Taiwan were taken for study. Each soil sample was treated with four methods of drying and determined by two extractants. To control PK-release/fixation on drying, chemical compounds (dextrose/octanol/water)were added either before or after drying. The relation between soil P and P-uptake as well as soil K and K-uptake was detected by the Neubauer test in which rice was used instead of rye seeds and soil was kept under submerging condition. The results may be summarized as follows:

1. The effect of drying on the availability index of soil P was extremely great especially in the case of the Bray P-1 test. However, the average increase of soil P-value on different methods of drying as compared to that of field moist soil was at 25%-40% for the Bray's method and 5%-32% for the Mehlich's method. The decrease was also found in Schist alluvial soils. The change of soil P on drying was found to be related to the C.E.C. and the contents of clay, Al-P, Fe-P, and Ca-P of the soil.

2. The soil K was almost unanimously increased by drying. However, the magnitude of increase was different from soil to soil. The average increase as compared to that of field moist soil was 15 %-30% and 20%-49% for the ammonium acetate and Mehlich's method, respectively. The C.E.C. was one of the dominant factors in responsoring the change of soil K on drying.

3. The control of PK-release/fixation on drying by addition of dextrose/octanol/water was found effective for certain soil but not for all soils.

4. Evidences from Neubauer test indicated that the available P determined by Bray's method with undried soil samples gave the best estimation of plant-available P in the soil. Those with air-dry rewet as well as air-dry octanol treated improved the estimation of available P over those obtainable with either air-dry or oven-dry soils. The relationships of Mehlich's P to the dry matter content or to the P-uptake of rice seedlings were insignificant. Soil K-value measured by ammonium acetate method was significantly related to the dry matter content as well as to K-uptake of rice seedliugs in spite of drying effect. It was also true in the case of Mehlich's method. As the release of soil K was closely related to the drying temperature, the condition for drying soil samples should be carefully controlled in order to avoid a fictitious recommendation for K fertilization.

LEAF ANALYSIS AS A GUIDE TO FERTILIZATION OF CITRUS TREE [1]

Mong—Ju YEN [2]

INTRODUCTION

The use of leaf analysis as a basis for fertilizer recommendation is now widely practised in the U.S.A., and there appears to be increasing interest in other citrus growing areas of the world.

Leaf analysis is used to determine the nutrient status of the tree. It is a valuable aid in obtaining a better understanding of the fertilizer requirements of citrus trees; however, the data obtained as a result of leaf analysis must be used in conjunction with other facts known about the tree.

The use of leaf analysis for evaluating the nutritional status of fruit trees assumes that yield, fruit quality, and plant growth are closely related to the concentration of essential minerals in the leaves at the time of sampling(2),(3). The quantity of an element in the leaves of a plant is a function of several interrelated factors(14),(15). Among these are leaf age, nutrient supply, moisture conditions, climatic conditions, soil type, crop load, and kind of plant(17). Leaf analysis integrates the factors that influence the content of nutrients in leaves up to sampling(4),(14),(15),(17). The physiological basis for leaf analysis rests on the following assumption: ⓐ nutrients absorbed from the soil are translocated throughout the plant but are concentrated primarily in the leaves; ⓑ the leaf is a primary site of plant metabolism; ⓒ leaf composition indicates change in nutrient supply, and ⓓ maximum yield and satisfactory fruit quality are quantitatively related to range of leaf analysis values(2),(3), (14), (15), (17). when the concentration of an essential element in leaves falls outside the optimum range for a crop like citrus, the addition or omission of that element in the fertilizer should produce a definite response(4). Reliable tables of leaf standards must be available for a particular tree crop before leaf analysis results can be properly evaluated(4),(14),(15). The quickest method of establishing approximate leaf standards is to conduct a survey of commercial planting with good production records(3). Leaf analysis values from these high yielding tree are used in setting up tentative optimum range for the essential mineral elements.

Reliable leaf analyses standards become available only after the results of surveys and sand culture experiment are tested against the values obtained from long term fertilizer experiment in the field(15).

Growers depend very heavily on leaf analysis to add minerals. The use of leaf analysis to indicate nutrient availability has long been accepted and its advantages and disadvantages have been recounted(14). However, its use as a practical tool has awaited the develop-

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ment of standards calibrated with differential treatments on producing tree under field condition ; and the growth of commercial laboratories capable of making critical and rapid analyses. In this paper some of the principles of leaf analysis and some of the factors that are particularly important for citrus are briefly discussed.

LEAF ANALYSIS STANDARDS

A certain level of nitrogen in the leaf has little meaning by itself. It must be related to standards. Fortunately 2 such sets of standards have been worked out for citrus. These are : 1, Some workers Chapman(4) and Deviller and Beyers(6) favor the use of a table of leaf standards compiled from the analysis of 4-to 10-month old leaves taken from fruit-bearing terminal shoots. These workers select leaves from fruit-bearing terminal shoot on the assumption that these leaves are easier to identify and sample. On the other hand, most of the other workers, e.g., 2. Smith(15), Jones and Embleton(8), and Koo(10), use standards based on leaves taken from non-fruiting terminal shoots. Smith(15) working with Florida sweet orange,uses a table of leaf standards based on 4- to 7-month old spring flush leaves taken from the middle of non-fruit-bearing shoot. Some workers Embleton and Jones(8) take leaves that are 5- to 7- months old based on the observation that there is a seasonal change in nutrient elements but the rate of change is not constant and the least change occurs in leaves at this time. Thus, this period is selected for sampling(8). There appears to be a trend towards the Smith(15), Embleton and Jones(8), Koo(10) standards based on non-fruit-terminal shoot. The reasons for this are : Firstly, the leaves from fruit-bearing terminal shoot show a much greater variation in macro-nutrient composition than leaves from non-fruit-bearing terminal shoot. Secondly, the crop load on a fruiting shoot affects the nutrient status of the leaves, especially in case of potassium and magnesium. Leaves on fruiting shoot have lower nutrient levels than those on non-fruiting shoot. Thirdly, leaves on non-fruiting shoots have a more direct influence on next seasons crop as most of the fruit will be borne on these shoot. In three cases the standards have been correlated with yield, fruit size and quality under a wide range of field conditions throughout the world(18).

RANGE OF MACRO AND MICRO ELEMENT IN CITRUS LEAF

A range of macro and micro nutrient leaf analysis values for citrus trees are shown in Table 1. An element is deficient when its leaf analysis value indicates a possible reduction in yield and fruit quality. Foliar symptoms will appear for most of the element when their leaf analysis values fall below specified minimum values(4),(15).

Nitrogen : Leaf values in the very low range are related to reduced yield and slightly reduced fruit quality for some elements. However ; low, but not deficient, values for element, such as nitrogen, are often associated with increased external fruit quality of orange (4),(9),(15), but high values of N increased green color of fruit. The nonuniformity of color of the high nitrogen fruit is due to more regreening on a portion of the surface of the fruit ; texture is coarsened ; peel thickness is increased ; percent juice is decreased ; and susceptibility to rind breakdown is increased(9).

Table 1. Satisfactory Range of Nutrient Element in Standard Samples of Leaves from Commercial Citrus Groves in Florida.

	Element	Chemical Symbol	Satisfactory Rang
macro	Nitrogen	N	2.3 —2.9
%	Phosphorus	P	0.09—0.15
	Potassium	K	1.2 —1.7
	Calcium	Ca	2.5 —5.0
	Manganese	Mg	0.30—0.45
micro	Copper	Cu	5 — 10
ppm	Iron	Fe	40 — 60
	Magnesium	Mn	20 — 75
	Zinc	Zn	25 — 80
	Boron	B	40 — 150

Phosphorus : The range indicated apply only when the nitrogen level in leaves falls to the optimum or lower range. If nitrogen is high or in excess, then the standards of classification tend to be displaced or invalidated, thus, phosphorus values inthe low range do not always indicate an inadequate supply of this element, and values in the optimum range associated with high nitrogen might actually increase to the excess range if the nitrogen supply were reduced without reducing phosphorus supply as reported by Smith(16).

When phosphorus is in the low range, yield may be reduced, and the fruit is well colored but otherwise of poor quality. when phosphorus is high, fruit color may be poor and juice quality somewhat low, but yeild unaffected(16).

Potassium : Potassium values in the leaves, about 0.7% will maintain yield but quality will be affected as discussed by Embleton, Jones and Platt(7). Potassium addition generally reduce the concentration of leaf magnesium regardless of the initial level. If it is relatively low, potassium application can induce or aggravate magnesium deficiency, as shown by Burns(3).

Potassium nitrate increased the nitrogen concentration in the leaves by 0.1%. That an increase in leaf potassium reduces the concentration of leaf calcium is a common occurrence(7).

A negative statistical correlation exists between high leaf potassium and soluble solid of orange as reported by Willson(17). Excess leaf analysis values may be related to decreased yield, inferior fruit quality, and reduced vegetative growth, Chapman(4) and Smith(16).

Calcium : High calcium in leaves usually indicates a calcareous soil in which availabilities of other major bases and some heavy metals are likely to be a problem with citrus(16). On neutral or acid soils, high leaf calcium usually reflects low availability of potassium either through high fixation by the soil or through inadequate ferilization on high acid,

low-exchange capacity soil. Leaf calcium is very responsive to the level of potassium fertilization. Thus, just as there is a relatively wide optimal range exists for calcium, a low concentration of calcium in leaves may be indicative of excess soil acidity. poor soil aeration, or unbalanced nutrition from excess element such as potassium, sodium, aluminum, copper, zinc, or manganese also affects availability of calcium. [13]

Magnesium : when manganese is low to deficient, chlorosis and defoliation are mild to severe, but quality is not adversely affected until the deficiency is severe[16].

Boron : If leaves are low on boron, it is likely to be associated with somewhat high phosphorus and manganese and low potassium values. A level of available boron in the soil sufficient to produce toxic concentration in leaves is likely to lower calcium and increase potassium concentration in leaves somewhat[16].

Iron, Copper, Zinc, Manganese: The heavy metals all tend to derange normal mineral metabolism when deficient. Deficiencies of these elements typically are associated with high nitrogen and potassium and low calcium in leaves. In fact, zinc deficiency was once thought to be a calcium deficiency because affected leaves were noted to be always abnormally low in calcium[16].

SAMPLING METHODS

Sampling is extremely important. A sample must be properly collected for an analysis is no better than the sample[8],[12].

In general, workers in Florida[16] select the use of 20 uniform tree in each grove for leaf sampling, but some workers in California[12] use 35–50 trees to make an adequate sample. In one young grove ; however, only 10 trees were according to a method used by Reitz and Long[13]. Depending on the size and shape of groves, one of 2 sampling patterns was employed. A diamond-shaped sampling pattern was used for sampling most of the larger, square—shaped groves. A zig-zag sampling pattern was suggested for the long narrow groves by Cooper[5]. Leaves are taken from the 4 sides of tree. These are taken from a north and east position from every other tree and south and west position from the alternate tree. The leaves are taken from the tree in the sampling pattern at a height of 1 to 7 feet above the ground[4],[12]. One leaf from each of about 10 exposed terminal around the periphery, combined with those from other tree, makes a sample [15]. Other workers[15] use a leaf sample consisting of 100 spring flush leaves, (5 leaves per tree) taken from the middle of non-fruit-bearing shoot on 20 trees in about the same tree-positional, sampling pattern.

SAMPLE PREPARATION

Leaves may be collected in the field in ordinary kraft Paper or plastic bags and either stored in an ice box or cold room at about 0 to 5°C until used or washed and placed immediately in the oven[16].

If they are to be washed, it is desirable to prevent them from wilting or drying out. A convenient routine washing procedure is to place the leaf sample in a 2 to 3 liter wide-mouth glass jar with a screw top, add about 500 mls. of 0.3 N HCl and about 1 gram of a

detergent such as a sodium laural sulfate, shake vigorously for 2 minutes, decant, then rinse and shake with 4 to 5 successive portions of distilled water in rapid succession until all the detergent is removed. Leaves should not be submerged long enough to cause translucent areas in them, indicating intrusion of the washing solution into the intercellular spaces of the mesophyll. In case of heavy residues difficult to remove, it may be necessary to scrub each leaf individually with acidified detergent solution. Leaves placed loosely in open paper bags should be dried to a constant weight in a force-draft oven at 50° to 65°C, then ground to a fine powder in a suitable mill (such as an intermediate-sized wiley) , thoroughly mixed, then stored in vermin-proof containers. Immediately before weighing out a portion for analysis, the powdered tissues should be redried for about 12 hours in an oven at a standard temperature 65°C(16).

ANALYTICAL METHODS

Nitrogen was determined by using a semi-micro Kjeldahl procedure described by Anderson *et al.* (1). the vanadate method was used for determining leaf phosphorus(1), calcium, manganese, potassium and other elements were determined with atomic absorption and flame emission procedures(11). The spectrographic technique for determination of certain micro-elements was used in several studies by Smith(15).

In a regular citrus leaf analysis program, leaf samples are obtained and nitrogen determined each year. However potassium, phosphorus, manganese, and calcium may be determined about every fifth year, if no problem is indicated in first analysis. Other elements, such as zinc, etc., are analyzed when one is needed to confirm conficiency symptoms, changes or adjustment in fertilizer application are then made on the basis of the analytical data with full knowledge of the past fertilizer history. This then, is the current status of leaf analysis as a guide to fertilization(8).

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柑桔葉片分析在施肥上之應用

嚴 夢 如

中 文 摘 要

葉片分析作爲柑桔施肥基準的方法，在美國已廣泛應用，因可直接診斷植株之營養狀況，更能瞭解其需肥程度，故在施肥上更爲精確，且經濟有效。本文就是柑桔葉片分析中有關採樣技術、樣品之製備、分析方法與各要素之含量標準等問題加以闡述，期能推薦於本省果農應用。

葉片分析受外界因子影響甚鉅，如葉齡、施肥、果實產量、品種、濕度、氣候與土壤狀況等。通常氮素每年分析一次，其他磷、鉀、鈣、鎂約五年分析一次，微量元素則依其葉部徵狀發生後加以分析。

柑桔黑星病菌侵入葉片之時期及子囊殼成熟度與子囊胞子釋放之關係[1]

黃秋雄、張曉麟[2]

一、前言

柑桔黑星病 (*Guignardia citricarpa* kiely) 屬潛伏性 (Latent infection) 病害 (1,3,4,6,9)。柑桔花落，幼果時期即有蒙受病原菌感染之可能 (1)。因其在葉片上之潛伏期長達1～3年 (6)，故葉片上鮮有病徵出現，而果實上之病徵，亦於果實成熟或貯藏期中方發生，致嚴重影響果實品質與外觀。早期認爲果園枯葉上形成之柄胞子 (Pycnidiospore) 爲其感染源 (1)。後因有性世代子囊胞子 (Ascospore) 之發現，並經證實果園枯葉成熟子囊殼 (Perithecia) 釋放之子囊胞子具有病原性，始瞭解該病之感染確切來源 (2,6,8,10)。

一般而言，植物病害之發生受環境因子影響甚巨。柑桔黑星病菌子囊殼之發育及子囊胞子之釋放，亦與環境因子有密切關係，瞭解環境因子對黑星病菌與寄主植物之變化，在病害防治上至爲重要。根據 Kiely 氏報告，溫度及土壤濕度影響黑星病之發生 (7)。露水 (6) 及下雨 (11) 影響病原菌子囊胞子形成與釋放。Mc Onie 氏謂南非一帶，子囊殼終年可在果園枯葉上產生，利用胞子採集器 (Hirst spore trap) 收集空中浮游子囊胞子之結果，顯示子囊胞子釋放集中於當地11月、12月及1月時期 (11)。然而子囊胞子之釋放與消長受氣象因子支配，因地而異。在本省，柑桔黑星病之研究頗多 (1,2,3,4,5,8)，但有關病原菌子囊胞子在果園之消長及其影響因子之報告，則尙缺乏。

本試驗乃利用胞子採集器收集果園內空中浮游子囊胞子，以瞭解子囊胞子在果園之消長情形。定期收集果園枯葉鏡檢子囊殼成熟度，觀察氣象因子對子囊殼發育與子囊胞子之影響，並利用組織分離法，探討黑星病菌侵入葉片之時期，供預防上之參考。

二、試驗材料與方法

本試驗胞子採集器之設置及病害標本之收集，均於新竹新埔椪柑果園內進行，玆分項說明於次。

1．果園內空中浮游子囊胞子之採集：

於果園之中心設置胞子採集器一架，每天在一定時間內，將經過10% Gelvatol 處理及塗有凡士林之玻片 (76×26mm) 置於採集器內，經過24小時後，取下保存，每隔2～3星期攜回室內，用0.1% Cotton-blue lactophenol 染色後鏡檢，觀察每日收集之子囊胞子數。根據胞子採集器之使用說明，計算每日每 m^3 空氣內含有之子囊胞子數。($N=\frac{M}{A\times hr}$，N：每日每 m^3 空氣內含有之胞子數，M：每日收集之胞子總數，A：胞子採集器每小時吸收之空氣量爲 $0.6m^3$，hr：每日收集胞子時數)。爲瞭解氣象因子對子囊胞子消長之影響，並記載果園內之降雨量、露水及溫度。

2．果園枯葉子囊殼成熟度之調查：

每月一至二次，前往果園內收集具有黑點狀之柑桔枯葉約50片，攜回室內，挑取枯葉上之黑點，用0.1% Cotton-blue lactophenol 染色鏡檢，依不同成熟度分成三級：(1) 無子囊和子囊胞子

本文承中國農村復興委員會邱博士人璋，本所植病系胡主任開仁、簡錦忠先生及朱啓魯先生等悉心指正，試驗期間，承李永松先生之協助，謹此致謝。

1 試驗報告農試字第五八七號。　2 臺灣省農業試驗所植物病理系技佐。

，（2）含子囊，（3）成熟子囊與子囊胞子。

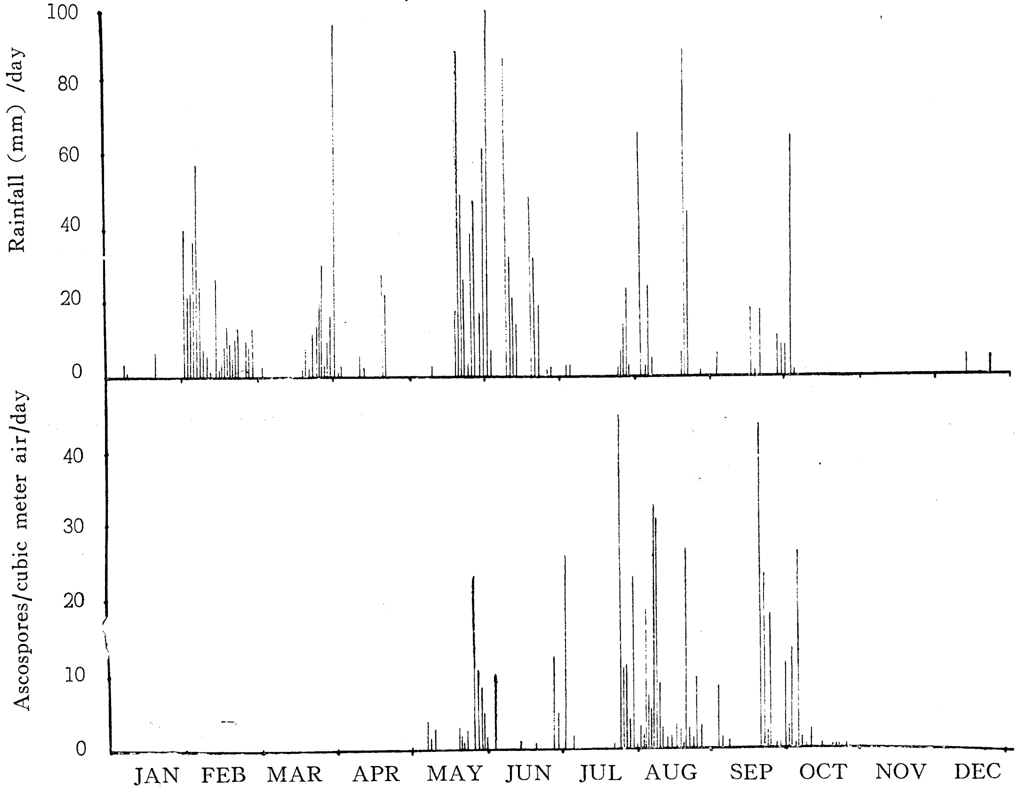
3．病原菌侵入葉片時期之探討：

於果園內選取固定10棵柑桔樹，在不同時期之春梢、夏梢及秋梢，每次逢機採集葉片50片，利用組織分離法，逢機切取直徑約 0.3mm 之組織共100塊，培養於 PDA (Potato Dextrose Agar) 上，置於 26°C 之定溫箱，經 1～2 星期後檢查黑星病菌出現之菌落數，以推測該菌侵入葉片之時期。

三、 試驗結果

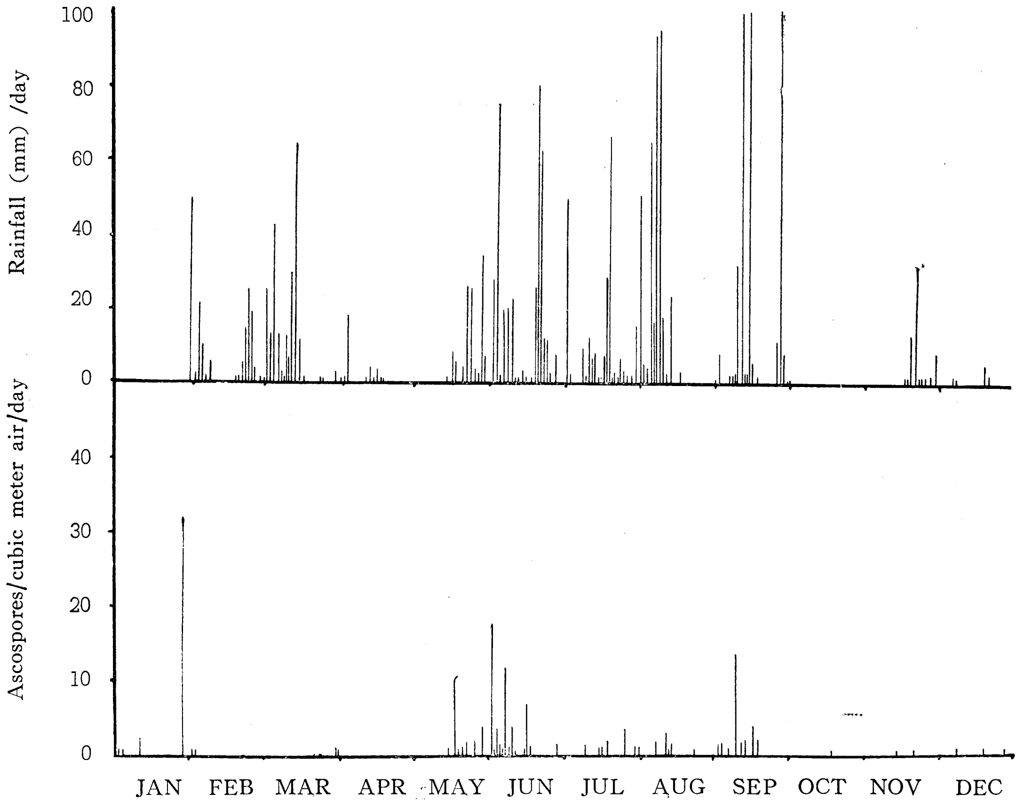
1．果園內空中浮游子囊胞子之消長情形：

本試驗自57年～59年，共進行三年之久，其結果如圖一、圖二及圖三。試驗過程中，因部份人為及氣象因子造成胞子採集器故障，或玻片模糊無法鏡檢者，其結果均視為無胞子出現，如圖二、58年9月底與10月初之間顯示之結果，係因該年9月26日颱風來襲，致採集器故障，無法採集胞子之故。就三年採集結果及氣象資料記載之分析，子囊胞子之釋放與下雨、溫度及露水有關。通常本省自5月以後溫度較高，雨量分配較均勻，因此子囊胞子之釋放，自5月下旬開始，一直延續至9月底或10月初，而後漸漸減少。一般而言，1～4月子囊胞子出現少，但從圖二、顯示，該年1月28日採集結果，其收集數達 32 Ascospores/m³ air ，是否受其他因子之影響，頗值探討。一年之中，6～9月胞子出現率最高，如圖四、所示。



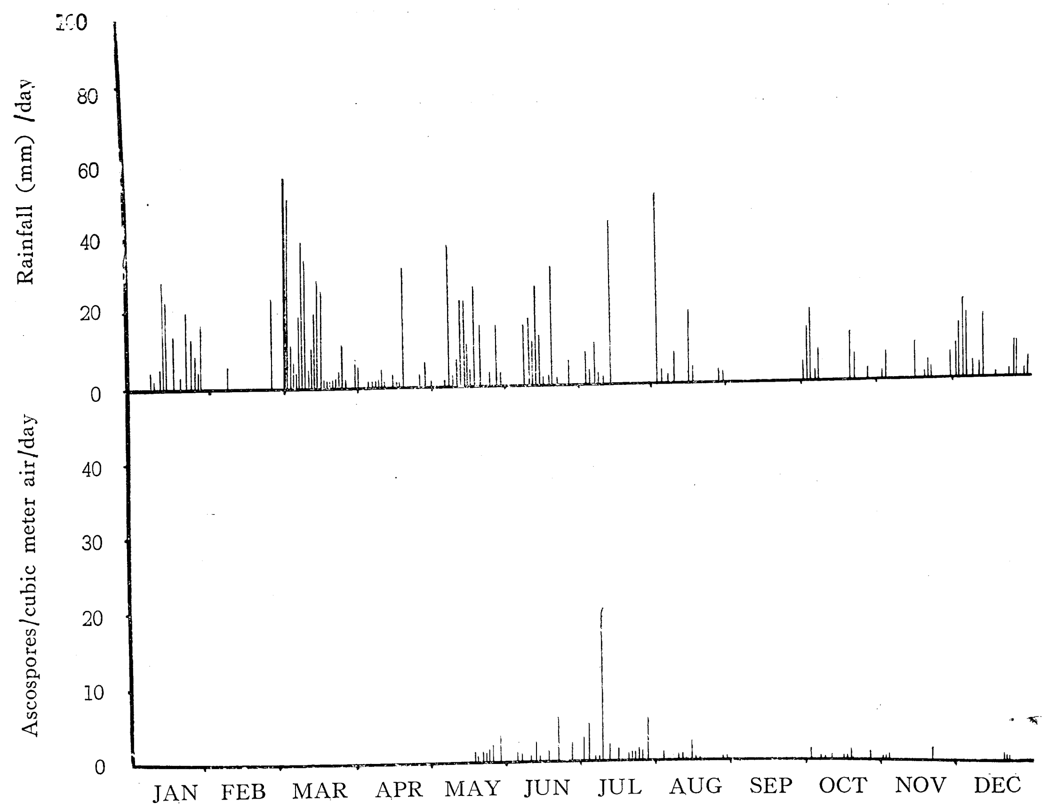
圖一、57年度新竹新埔柑桔果園黑星病菌子囊胞子釋放與雨量之關係。

Figure 1. The relationship between discharge of *Guignardia citricarpa* ascospores and rainfall. Spore trapping was made from Jan. to Dec. of 1968.



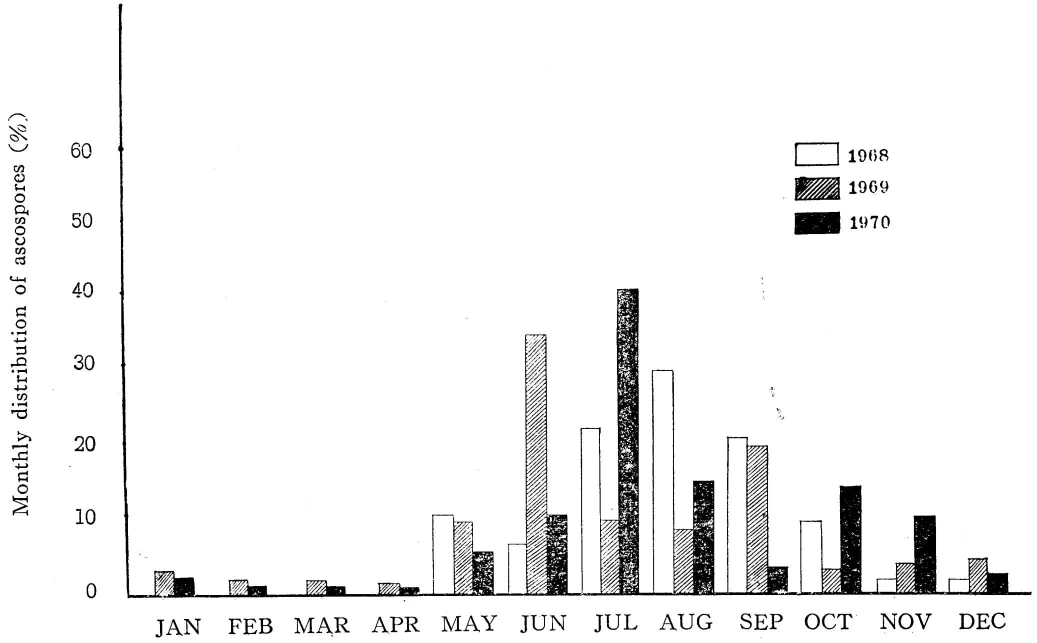
圖二、58年度新竹新埔柑桔果園黑星病菌子囊胞子釋放與雨量之關係。

Figure 2. The relationship between discharge of *Guignardia citricarpa* ascospores and rainfall. Spore trapping was made from Jan. to Dec. of 1969.



圖三、59年度新竹新埔柑桔果園黑星病菌子囊胞子釋放與雨量之關係

Figure 3. The relationship between discharge of *Guignardia citricarpa* ascospores and rainfall. Spore trapping was made from Jan. to Dec. of 1970.



圖四、57年至59年新埔柑桔果園黑星病菌空中浮游子囊胞子每月出現之百分率。

Figure 4. Monthly distribution of ascospore discharge of *Guignardia citricarpa* as determined by spore trapping made in Hsin-pu orchard from 1968 to 1970.

2. 果園枯葉子囊殼成熟度之調查：

爲瞭解柑桔枯葉上子囊殼成熟度與子囊胞子釋放之關係，59年度開始進行該項調查，除新埔果園外，同時於臺中及嘉義兩處果園進行調查。通常1～4月間，子囊殼形成率低，7～9月爲子囊胞子釋放時期，但因溫度高，雨量多，且分配較均勻，果園落葉數日後即腐爛或埋藏於泥土裡，殊難收集完整枯葉。臺中及嘉義兩處所作調查，因收集數量太少，次數不夠密集，致未能獲得一致之結果。僅就新埔地區調查之結果列表於後：

表一、59年度新竹新埔果園枯葉子囊殼成熟度調查

Table 1. Perithecial development of *G. citricarpa* on dropping leaves of Citrus in Hsin-pu orchard in different times of 1970.

收集日期 Date of collection	收集葉片總數 Total leaves collected	子囊殼成熟度等級 (Stages of development of perithecia)		
		無子囊和子囊胞子 Without asci & ascospores (%)	含子囊 With asci (%)	成熟子囊和子囊胞子 With asci & ascospores (%)
Jan. 21	50	6.0	78.0	16.0
Feb. 27	50	62.0	6.0	32.0
Mar. 24	50	80.0	12.0	8.0
Apr. 29	42	47.7	47.6	4.7
May 16	30	56.7	33.3	10.0
May 31	50	54.0	40.0	6.0
June 18	30	26.7	10.0	63.3
July 8	10	40.0	30.0	30.0
July 22	40	50.0	25.0	25.0
Aug. 22	30	76.8	6.6	16.6
Sep. 14	50	62.0	2.0	36.0
Oct. 14	20	80.0	20.0	0
Nov. 8	30	3.4	90.0	6.6
Nov. 26	50	62.0	38.0	0
Dec. 23	40	37.5	60.0	2.5

3. 病原菌侵入葉片時期之探討：

利用組織分離法，從健全柑桔葉片分離黑星病菌落數，所得結果如表二及表三。通常春梢萌芽時期約在三月底或四月初，而組織分離所得結果顯示，在五月下旬或六月初可獲得多量黑星病菌落數。夏梢及秋梢萌芽時期，分別在五月下旬及八月中旬左右，萌芽後約一個月即可分離多量病原菌菌落數。從分離而得之不同菌株，通常在培養基上表現兩種不同類型，即生長快速型及生長緩慢型，前者可在培養基上發現子囊及子囊胞子，而後者只產生較多之柄胞子。

表二、58年度新竹新埔椪柑葉片不同時期分離黑星病菌之結果（菌落數/100組織塊）

Table 2. Isolation of *G. citricarpa* from Ponkan leaves collected in different times from Hsin-pu orchard in 1969. (colonies/100 tissue pieces*)

分離菌落數 No. of colonies / 不同梢期 Type of buds	分離日期 (Date of isolation)										
	Apr. 13	May 1	May 31	June 18	July 8	July 22	Aug. 21	Sept. 14	Oct. 14	Nov. 5	Nov. 26
春梢 Spring bud	0	2	16	10	7	17	23	—	—	—	—
夏梢 Summer bud	—	—	—	—	1	3	11	11	—	—	—
秋梢 Fall bud	—	—	—	—	—	—	—	16	19	15	17

* Diameter of tissue pieces : 0.3mm.

表三、59年度新竹新埔椪柑葉片不同時期分離黑星病菌之結果（菌落數/100組織塊）

Table 3. Isolation of *G. citricarpa* from Ponkan leaves collected in different times from Hsin-pu orchard in 1970. (colonies/100 tissue pieces *)

分離菌落數 No. of colonies / 不同梢期 Type of buds	分離日期 (Date of isolation)										
	Apr. 15	May 5	June 9	June 16	July 14	Aug. 11	Aug. 24	Sept. 14	Oct. 13	Nov. 12	Dec. 3
春梢 Spring bud	1	2	3	8	6	12	—	—	—	—	—
夏梢 Summer bud	—	—	—	—	3	—	7	17	18	16	22
秋梢 Fall bud	—	—	—	—	—	—	0	5	11	12	19

* Diameter of tissue pieces=0.3mm.

四、討　　論

柑桔黑星病之感染源爲果園枯葉上病原菌成熟子囊殼釋放之子囊胞子 (6,8,10,11)。 果園中子囊胞子之消長，直接影響果實及葉片侵入期。在本省新竹新埔黑星病菌子囊胞子之出現，自五月下旬至九月底或十月初，其持續時期長達4個月。從過去不同時期之藥劑撒佈、套袋試驗(8)及葉片組織分離之結果，顯示果實及葉片之初次侵入期與子囊胞子開始釋放之時期相吻合。由於果實成熟具有抵抗性 (2,11) ，據李氏報告，果實成熟抵抗性之時期，約在八月中旬與十月初之間(2)。若就子囊胞子之釋放時期觀之，則黑星病可能有數次果實侵入期，而其時期則介於五月下旬至八月之間。

氣象因子影響黑星病菌子囊殼發育與子囊胞子之釋放。 Kiely 氏利用乾濕交替法 (Periodic wetting and drying) ，處理收集之果園落葉，誘導子囊殼形成(6)，可知乾、濕狀況下有利於該病菌子囊殼之發育 。Mc Onie 氏謂下雨影響子囊胞子之釋放，大量子囊胞子釋放緊跟着下雨之後(11)。溫度亦影響子囊殼形成與發育（未發表資料）。根據氣象紀錄分析，本省周年氣溫變化顯著，日平均溫以一至二月最低，約 15°C 左右，三月中旬以後，逐漸昇高，七至八月溫度最高，約 28～29°C。五月至九月由於氣溫較高，雨量分配較平均，適於子囊殼之發育，因此子囊胞子之釋放集中於此時期。

露水對黑星病菌子囊殼形成之影響，意見不一， Kiely 謂露水影響子囊胞子之釋放(6)。 Mc Onie 謂灌漑及露水對子囊胞子之釋放無顯著影響(11)。從胞子採集之結果， 58 年 1 月 28日其採集數達 32 Ascospores/m^3 air，而且其釋放集中於夜晚，此種現象頗值探討，考諸氣象因子， 該日下午起大霧，因此推測，成熟子囊殼在適當溫度下，露水可能有助於子囊胞子之釋放。若以三年所採集結果比較，則57年收集之胞子數超過58及59年之胞子總和，此種現象可能因藥劑撒佈之結果，減少感染源侵入柑桔葉片，使翌年子囊殼成熟率頓形減少。

又定期收集果園枯葉，檢查子囊殼成熟度，其結果不一。上半年收集之枯葉，子殼囊成熟度低，但下半年因溫度高，雨量分配較均勻，果園落葉容易腐爛，收集困難，致影響檢查之結果。

柑桔黑星病爲本省柑桔貯藏之重要病害，如何適時施藥防治，實爲吾人致力之目標。若能徹底瞭解黑星病之感染適期及感染源與氣象因子之關係，則可據以確立黑星病之防治步驟。本文僅就病原菌子囊胞子在新埔果園消長之情形，病原菌侵入葉片時期及影響因子，簡述觀察結果，俾有助於防治之參考。

五、摘　　要

柑桔黑星病病害之發生受氣象因子影響甚大。下雨、露水及溫度均能影響病原菌子囊殼發育及子囊胞子之釋放。本省新竹地區，黑星病菌子囊胞子之釋放，自五月下旬至九月底或十月初，其釋放時期長達四個月。由葉片組織分離之結果，黑星病菌初次侵入葉片時期與子囊胞子開始釋放之時期相互一致。通常春梢萌芽後二個月，即大量受感染，而夏梢及秋梢萌芽後不久即有可能受感染。從定期檢查果園枯葉子囊殼成熟度之結果，無法有效預測子囊胞子之釋放時期。

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LEAF INFECTION WITH CITRUS BLACK SPOT AND PERITHECIAL DEVELOPMENT IN RELATION TO ASCOSPORE DISCHARGE OF *GUIGNARDIA CITRICARPA* KIELY

by

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SUMMARY

This paper deals with the discharge of ascospore of the citrus black spot fungus, *Guignardia citricarpa* Kiely, as affected by environmental factors. Some relevant results of leaf infection and investigation of perithecial development were also given.

Using a Hirst spore trap for collecting ascospores during 1968—1970, it was found the most favorable period for ascospore discharge occurred from the end of May to early October. Rain and high temperature were important to induce the development of perithecia and discharge of ascospore. When there were mature perithecia in orchard, heavy dews could probably be effective in inducing ascospore discharge. In the Summer, the climatic factors were favorable for ascospore discharge and a large amount of such spores were released. Ascospore discharge Occurred at a very low level during the Winter and early Spring. The results of spore trapping and tissue isolation made from apparently healthy leaves indicated a coincidence of initial leaf infection with the commencement of ascospore discharge in the late part of May.

The perithecia of *Guignardia citricarpa* were present in citrus dead leaves throughout the year in Taiwan. Detection of initial ascospore discharge of the pathogen was attempted by examination of dead leaves for mature perithecia. The experiment was begun in January and carried through December 1970. Unfortunately, monthly examination of perithecia failed to give a meaningful result. The reason may be due to the small samples taken and the rapid decomposition of leaves during the hot Summer and raining season.

亞麻不同收穫期對產量及纖維品質影響之研究[1]

熊光斗[2]　蔡焜煌[3]　韓青梅[4]

一、前　言

本省亞麻纖維品質甚差，僅能供混紡之用，售價祇及歐洲產品之61%；又其原莖製纖率低下，正線率平均僅8.4%，短線率爲6.3%，而日本所產原莖之正線率爲14.9%，相差達 6.5%，故省產原莖價格不高，麻農栽培亞麻利益不大，興趣因而低落，影響栽培面積之推廣。亞麻正線爲本省外銷物資之一，在日本有良好市場；其短線則爲製造高級紙張原料，年來本省製紙工業頗發達，高級紙張原料甚爲缺乏，目前本省亞麻纖維產量，猶感不足，尙需擴展栽培面積；尤應謀求增加原莖之製纖率及提高纖維品質，藉以提高原莖價格，俾能增加麻農收益，以利生產。

本省栽培亞麻，生育期間之氣候條件與世界主要亞麻產地不同，據王祖濤(1940)報告，亞麻栽培之適度氣溫爲 10～20°C，歐洲、日本等地亞麻栽培之氣溫在生長初期爲 10°C 左右，生長期中氣溫逐漸上昇，月平均氣溫不超過 17.5°C；日照爲 15～16 小時之長日照。D. M. Yermanos & J. R. Goodin (1965) 報告，氣溫 15.6°C 植株生長最爲健壯，葉之大小及葉色均爲正常。本省亞麻生長初期之平均氣溫爲 20°C 左右，生長中期低至 14.5°C 以下，生長後期氣溫再告上昇，故其生長期間氣溫分佈並不理想，尤其生長期氣溫昇高，使後期生長過速，且有第 2 次生長。生長期間之日照爲10～11小時，故其開花期間延長，此二因子均遭致本省亞麻生長日期之延長。

據友田五郎 (1959) 資料，在日本北海道亞麻之生育期，播後57日始花，62日盛花，85～99日收穫。本省之生育期爲播後49～53日始花，63～65日盛花，104～113日收穫，二者之花期甚爲接近，所不同者爲自盛花至收穫期之日數，前者爲23～37日，後者爲41～48日。本省亞麻收穫因係以種子成熟期爲準，亞麻生育後期因氣溫增高而有第 2 次生長，其開花期間延長，種子陸續成熟，因而收穫期延遲，自盛花至收穫需要之日數乃較日本北海道者爲多。據張拔倫 (1947) 報告，亞麻於發芽後40天，纖維細胞及纖維束開始發育，至開花前後 1 個月內爲纖維細胞發育之盛期。故就纖維而言，其成熟日數需否如此多天數，其纖維是否過熟而影響其品質與正線率，尙應加以研究。本研究爲從收穫時期探討對產量與品質之影響，冀求得兼顧種子與原莖之產量及品質之適當收穫期，以發展本省亞麻之生產。

二、研究材料與方法

(一) 田間試驗

本試驗供試品種爲臺中選 1 號，收穫期分發芽後 80天，90天，100天，110天及120天收穫等 5 處理，用完全逢機區組設計，重複 6 次，小區面積7.2平方公尺，畦長 6 公尺，畦寬1.2公尺，撒播，播種密度2400株/平方公尺，試驗地點在臺中市南屯區。

(二) 製纖率之測定及纖維品質考查

(1) 製纖率之測定：田間試驗收穫之亞麻原莖，按小區分別整理捆束，置於浸練池內精練，至可分離纖維時取出曬乾，以碎莖器碎莖後，用採纖機製成正線，脫落之亂纖維及短纖維以短纖機製成短線，秤計重量，並以原莖爲比率，計算各處理之正線率及短線率。

本研究蒙國家科學委員會補助，謹此致謝。

1. 試驗報告農試字第五八八號。

2、3、4、臺灣省農業試驗所臺南棉麻試驗分所技正、技士、技佐。

（2）纖維品質考查：製成之正線，採用臺灣工礦公司亞疏廠外銷分級標準，按照處理小區分別評定等級，然後每小區隨機取樣重5公克之樣品10個，供作測定拉力與纖度之試驗材料。拉力測定爲切取樣品中央部份之纖維以 15支/吋之櫛梳整梳，製成長90公厘，重 0.09 公克之樣品 10 個，以吉田式拉力機測定夾間1公分之拉力。纖度測定爲切取已整梳長3公分之樣品 10 個，數計單纖維數，以Torsion balance 預計重量，計算其纖度。

（三）亞疏橫切面組織及纖維細胞之觀察

每處理各小區隨機取樣中庸疏株 10 支，切取莖中央部份長 5 公分疏莖一段，以 FAA 液固定，然後切片，每莖選取一切片供觀察橫切面組織，即每小區觀察 10 次，取2切片觀察纖維細胞組織，每片觀察 10 個，即每小區觀察 20 次。切片全部用 Phloroglucin 染色，在顯微鏡下用測微計（Micrometer）觀測莖橫切面各層組織之厚度，纖維細胞之大小與各層厚度，及計數細胞數目與束數等。

三、試驗結果與討論

本試驗田間試驗在臺中市南屯區辦理，於59年11月25日播種，60年3月30日收穫完畢。疏莖由亞疏廠代爲精練成乾莖後，由本分所採製纖維及測定纖維品質。供顯微鏡觀察之疏莖樣品，係於每期收穫時分別取樣。各項試驗結果如下：

（一）生育特性

表1. 亞疏不同收穫期生育特性調查表

Table 1. An investigation of characteristics of flax at different harvesting periods

收穫期 Harvesting periods	株高 Plant height (cm)	莖長 Length of stem (cm)	莖徑 Diameter of stem (mm)	分枝數 No. of branches per plant (No.)	蒴果數 Capsules per plant (No.)	每蒴種子數 Grains per capsules (No.)	千粒重 Weight of 1000 seeds (g/1000 seeds)
發芽後 80 天 80 days after emergence	75.8	70.8	1.43	1.7	1.0	4.6	1.86
發芽後 90 天 90 days after emergence	77.8	71.0	1.38	2.4	3.4	6.0	2.15
發芽後 100天 100 days after emergence	78.4	71.3	1.38	2.5	3.9	7.1	2.91
發芽後 110天 110 days after emergence	77.6	69.9	1.40	1.9	3.6	6.9	3.70
發芽後 120天 120 days after emergence	77.8	70.1	1.39	2.0	3.6	7.1	3.86

由上表知株高、莖長、分枝數，發芽後90天以後已不再增長，莖徑於90天較80天反略減少，90天以後已無增減，故營養生長在90天已告停止。蒴果數，每蒴種子數自80天至100天仍逐次增加，100天至120天則不再增加，故至100天時蒴果數及種子數已趨固定。千粒重則收穫愈晚愈增加，故生殖生長自80天至120天之間迄未停止，種子仍在逐步充實中。

(二) 產量比較

表2. 亞麻不同收穫期產量比較表

Table 2. Yields of flax at different harvesting periods

收穫期 Harvesting periods	原莖產量 Yields of dry straw		纖維產量 Yields of fibers						種子產量 Yields of seeds	
			正線 Line fibers		短線 Cottonized tow		纖維總量 Total			
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
發芽後 80 天 80 days after emergence	6,688	82.9	424.1	43.7	407.6	126.0	831.8	64.3	0.3	0.2
發芽後 90 天 90 days after emergence	7,653	94.9	772.0	79.6	308.6	95.4	1,080.6	83.6	175.0	13.1
發芽後 100天 100 days after emergence	7,690	95.4	863.0	88.9	340.6	105.3	1,203.6	93.1	698.6	52.4
發芽後 110天 110 days after emergence	8,401	104.2	1,003.9	103.5	328.1	101.4	1,331.9	103.0	1,137.5	85.4
發芽後 120天 120 days after emergence	8,060	100.0	969.7	100.0	323.3	100.0	1,293.1	100.0	1,332.0	100.0
L. S. D. 5%	363.1	—	63.4	—	40.3	0	128.9	—	98.5	—
L. S. D. 1%	493.5	—	86.5	—	54.9	—	155.7	—	133.8	—

據變量分析結果，各項產量處理間差異均極顯著。原莖產量，正線產量及纖維總量均以發芽後110及120天之收穫期最高，此二期間差異不顯著，但均顯著優於其他各收穫期。其他各期則愈早收穫產量愈低，發芽後80天最低。短線產量以發芽後80天爲最高，顯著優於其他各收穫期。其他各期間差異不顯著，此顯示在 80 天期間纖維發育尚未全部完全，故其正線少，纖維總量少，短線多，而需至110天纖維方始成熟。以上情形，可知就原莖及纖維產量而言，本省亞麻應以發芽後 110天及120天收穫最爲有利。種子產量各處理間差異極爲顯著，愈晚收穫產量愈高，每期與每期間之差異均極顯著，以發芽後120天最高，其產量較發芽後110天高14.6%，發芽後 100天者僅及 120天者之半數。故就原莖，纖維，種子產量言，本省亞麻收穫期應以發芽後120天收穫最宜，其原莖及纖維產量與發芽後110天者無顯著差異，而種子可增產14.6%。

（三）製纖率與纖維品質

表3. 亞麻不同收穫期之製纖率及纖維品質

Table 3. Quality of flax fiber and the rate of retted fiber at different harvesting periods

收穫期 Harvesting periods	製纖率 Rate of retted fibers			纖維品質 Quality of flax fibers			
	正線率 Percent of line fibers (%)	短線率 Percent of cottonized tow (%)	總製纖率 Percent of total fibers (%)	正線等級百分比 Grade of line fibers (%) L_3	L_4	正線拉力 Tensile strength of line fibers (kg)	正線纖度 Denier of line fibers
發芽後80天 80 days after emergence	6.4	6.2	12.56	0	100	15.4	39.87
發芽後90天 90 days after emergence	10.2	4.1	14.19	19.4	80.6	21.7	40.35
發芽後100天 100 days after emergence	11.3	4.5	15.81	25.0	75.0	24.9	43.13
發芽後110天 110 days after emergence	12.0	3.9	15.99	75.0	25.0	30.3	45.47
發芽後120天 120 days after emergence	12.1	4.0	16.51	92.0	8.0	29.4	42.50
L. S. D. 5%	0.60	0.44	0.81	—	—	2.35	3.89
L. S. D. 1%	0.82	0.60	1.10	—	—	3.23	5.29

據變量分析結果，各項製纖率差異均極顯著。其中正線率隨收穫期之延後而逐期增高，以發芽後120天及110天最優，此2期間差異不顯著，但均顯著高於其他各收穫期。短線率以發芽後80天最高，發芽後100天次之。總製纖率一如正線率，有隨收穫期之延後而逐期增高之現象，以發芽後120天最高，110天及100天次之，但此3期間差異不顯著，而均顯著高於其餘2期，故就製纖率而論，應以發芽後120天及110天收穫爲宜。120天略優於110天，此2期之正線率及總製纖率均高。

纖維品質之拉力與纖度，各期之差異均爲顯著。拉力以發芽後110天最大，120天次之，但此2期間差異不顯著，而均顯著大於其餘各期。纖度以發芽後110天最大，其纖維較粗，其他各期間差異不顯著。正線等級以發芽後120天最優，分佈在 L_3 之正線有 92%，發芽後 110天次之，分佈在 L_3 之正線爲 75%，其餘各期隨收穫期之提前而逐期減少，故纖維品質以發芽後 120 天爲最優，110 天次之。

（四）橫切面組織之觀察

表4. 亞麻不同收穫期莖橫切面組織調查表

Table 4. Measurement of the tissues of flax stem in cross section at different periods

項目 Items		發芽後80天 80 days after emergence	發芽後90天 90 days after emergence	發芽後 100天 100 days after emergence	發芽後 110天 110 days after emergence	發芽後 120天 120 days after emergence
莖各層組織厚度 Thickness of tissues of stem in cross section	莖直徑 Diameter of stem(mm)	1.85	2.06	1.88	1.83	1.78
	靭皮部厚 Thickness of phloem (mm)	0.13	0.14	0.14	0.12	0.12
	木質部厚 Thickness of xylem (mm)	0.32	0.37	0.32	0.31	0.30
	髓部厚 Thickness of pith (mm)	0.95	1.03	0.98	0.96	0.93
	靭皮部百分比 Percent of phloem thickness in cross section	14.23	13.97	14.54	13.54	14.03
	木質部百分比 Percent of xylem thickness in cross section	34.39	36.22	33.53	34.05	33.82
	髓部百分比 Percent of pith thickness in cross section	51.38	49.81	51.93	52.42	52.44
纖維細胞數 No. of fiber cells		482	563	532	495	473
纖維細胞束數 Bundles of fiber cells		29	31	31	31	30
纖維細胞大小及各層厚度 Size and thickness of fiber cell	細胞直徑 Diameter of cell (μ)	24.85	25.48	26.52	26.40	26.36
	細胞壁厚 Thickness of (μ) cell wall	9.11	9.16	9.25	9.20	8.87
	中腔厚 Thickness of Lumen (μ)	6.63	7.16	8.02	8.00	8.62

表5. 亞麻不同收穫期莖內部組織與製纖率、正線拉力及纖度之關係

Table 5. Relationship of the quality of line fiber and the rate of retted fiber fiber to the tissues of flax stem

項目 Items			製纖率 Rate of retted fiber	纖維拉力 Tensile strength of line fiber	纖度 Denier of line fiber
莖橫切面組織 The tissues of stem in cross section	靭皮部百分比 Percent of phloem thickness in cross section	r	+ 0.253	—	—
		t	+ 0.728		
	木質部百分比 Percent of xylem thickness in cross section	r	− 0.489	—	—
		t	− 0.972		
	髓部百分比 Percent of pith thickness in cross section	r	+ 0.614	—	—
		t	+ 1.349		
	纖維細胞數 No. of fiber cells	r	− 0.117	—	—
		t	− 0.204		

纖維細胞厚度 Thickness of fiber cell in cross section	細胞直徑 Diameter of fiber cells	—	r + 0.914* t + 8.430	r + 0.844 t + 2.730
	細胞壁厚 Thickness of cell wall	—	r + 0.722 t + 1.800	r + 0.366 t + 0.711
	中腔厚 Thickness of lumen	—	r + 0.924 t + 1.301	r + 0.728 t + 0.890

莖橫切面各層組織厚度各收穫期間之差異均不大，以發芽後 90 天最厚，以後各期略爲減少，至 120 天最小。厚度之減小程度以木質部爲較多，其次爲韌皮部，然後爲髓部，故各層組織發育至90天以後已不再增厚，反有減少，此應係營養生長已告停止，在成熟階段各層組織中水份減少所致。各層厚度與莖直徑之百分比，以髓部最大，其次爲木質部，最小爲韌皮部。各收穫期韌皮部百分比之差異甚小，木質部及髓部百分比之差異較大。木質部百分比以 90 天最大，以後各期較小。髓部百分比以90天最小，以後各期逐期增大，至120天最大。由表 5.之分析資料，顯示韌皮部厚百分比及髓部厚百分比對製纖率之關係爲正相關，木質部厚百分比爲負相關，此與製纖率之逐期增加恰爲一致。此二部份厚度之百分比應爲直接影響製纖率高低之因子。又120天之木質部百分比較110天者小，韌皮部之百分比較110天者大，故在莖內部組織方面120天較 110天爲優。纖維細胞個數與製纖率之關係爲負相關，但其差異極小，t 值僅0.204，而差異標準爲 3.12，故在本研究中纖維細胞個數對製纖率無影響。

纖維細胞直徑自發芽後80天至 100天逐期增加，以後各期差別極小。纖維細胞壁厚各期間差異甚小，惟顯示有自80天至100天逐期增加，以後各期逐期略有減小之情形。中腔厚自80天至120天逐期增加。由此可知纖維細胞至發芽後100天已發育完成，至110天進入成熟階段，水份逐漸減少，細胞壁厚減少，中腔增大。據表5.分析結果，細胞直徑與拉力成顯著之正相關，與纖度亦爲正相關，t 值接近顯著標準，細胞壁厚及中腔厚對纖維拉力及纖度均爲正相關，但均未達顯著程度，故纖維細胞之大小影響拉力最大，亦影響纖度之增大，細胞壁厚及中腔厚影響拉力及纖度較小。由纖維品質之測定，正線拉力自80天至110天爲逐期增加，110天與120天間無顯著差異。纖度自80天至110天亦爲逐期增加，100天至120天間無顯著差異，各收穫期纖度之差異與纖維細胞直徑大小之差異甚爲吻合，正線拉力自80天至100天與各期細胞之大小及細胞壁厚之差異吻合，惟 110天及120天 2 收穫期纖維細胞之大小與100天無差異，細胞壁厚較100天小，而正線拉力反顯著高於100天，此應係在100天時纖維細胞已發育完成而尚未成熟所致。

四、結　　論

綜合以上試驗測定結果，本省亞麻之收穫期以發芽後 120天最爲有利，其原莖產量、纖維產量僅較110天者減少 3 ～ 4 %，而種子產量可增加14.6%，其正線率及短線率均不較110天者低，而總製纖率增加0.52%，雖正線拉力減少0.9公斤，而纖度較110天者小，纖維較細，且正線等級較 110天者爲優。

由莖組織之調查，知植株至90天始停止營養生長，纖維細胞至 100天方始發育完成，但尚未成熟，如提前至發芽後90天收穫，則製纖率及纖維拉力均顯著降低，纖維及種子產量均急劇下降，故本省亞麻生育期必需達110天後方可收穫。

五、摘　　要

本研究之目的爲探究亞麻收穫時期對原莖、纖維與種子產量，及原莖製纖率與纖維品質之影響，冀求得兼顧種子與原莖產量及品質之適當收穫期，以供發展本省亞麻生產參考之用。

本研究分田間試驗、製纖率與纖維品質之考查、及莖內部組織之觀察三步驟進行。田間試驗處理

項目分發芽後80天、90天、100天、110天及 120天收穫等5種，用逢機完全區組設計，重複6次，在臺中市亞麻產區辦理。原莖之精練在亞麻廠辦理。採纖在本分所嘉義工作站辦理。品質考查及莖組織觀察在本分所研究室進行。試驗結果摘錄如下：

1. 亞麻植株營養生長，在發芽後90天已告停止，其株高、莖長、莖徑、分枝數至90天後已不再增長。生殖生長自發芽後80天至120天間迄未停止，其每株蒴果數及每蒴種子數至發芽後100天方始固定，種子自發芽後110天至120天仍在充實中。

2. 原莖產量、正線產量，及纖維產量以發芽後110天及120天收穫最高，顯著優於其他各期，而此二期間無顯著差異。此二期較最接近之100天收穫期原莖增產4.6～8.8%，正線增產 11.1～14.6%，纖維總量增產6.9～9.9%。種子產量以發芽後120天收穫最高，較110天增產14.6%，較 100天增產47.6%。

3. 各收穫期之製纖率以發芽後120天及110天最優，其正線率為12.1～12.0%，均顯著高於其他各期，總製纖率亦高，為16.51～15.99%。

4. 纖維品質以發芽後120天最優，其次為110天，此二期之正線拉力均顯著優於其他各期。纖度則110天較差。正線等級以120天最優，其分佈在 L_3 級者佔92%，L_4 級者為8%，而110天之正線分佈在 L_3 者為75%，L_4 級者為25%。

5. 各期莖橫切面各層組織與製纖率之關係：韌皮部厚之莖徑百分比及髓部厚之莖徑百分比，對製纖率為正相關，木質部厚之莖徑百分比對製纖率為負相關。各收穫期韌皮部厚之莖徑百分比差異甚小，木質部之莖徑百分比以發芽後90天最大，以後各期較小，髓部厚之莖徑百分比以發芽後90天最小，以後各期逐期增大，至 120天最大，此與各期之製纖率逐期增加正相吻合，又莖內部組織 120天較110 天為優。

6. 各期纖維細胞組織與纖維拉力及纖度之關係：纖維細胞組織至發芽後 100天已發育完成，細胞大小及細胞壁厚不再增大，110 天進入成熟階段，細胞壁逐期減小，中腔增大。細胞直徑、細胞壁厚及中腔厚對纖維拉力及纖度均為正相關。各收穫期纖度之差異與細胞直徑之差異尚為一致。拉力之增加自80天至100天與細胞直徑及細胞壁厚之差異吻合，110天及 120天拉力之增加為纖維細胞成熟所致。

7. 綜合以上結果，本省亞麻之收穫期以發芽後120天最為有利，其原莖產量、纖維產量僅較110天者減少3～4%，而種子產量可增加 14.6%，其正線率及短線率均不較110天低，而總製纖率增加0.52%，雖正線拉力減少0.9公斤，而纖度較小，纖維較細，且正線等級較110天者為優。

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EFFECTS OF HARVESTING DATES ON FIBER YIELD AND QUALITY OF FLAX[1]

K. T. Hsiung[2], K. H. Tsai[3], C. M. Hain[4]

Summary

The purpose of this investigation is to study the effect of flax harvesting dates upon the yield of straw, fiber and seed, the fiber rate of straw, and the fiber quality, in order to improve flax production in Taiwan by means of appropraite harvesting date.

There are three aspests involved in field experiment to measure retted fiber rate and fiber quality, histological observation of internal tissues of stem. The 5 harvesting dates are 80 days, 90 days, 100 days, 110 days, and 120 days after emergence. Randomized block with 6 replications were used in the field experiment conducted in the flax district of Taichung city. The retting of straw takes place in the Flax Fiber Factory. The fiber scutching process is conducted in Chiayi Experiment Farm, Tainan Fiber Crops Experiment Station. The measurement of quality and histological observation of stem were made in the laboratory of this station.

The results of the experiment are summarized as follows :

1. The vegetative growth of flax plant ceases at 90 days after emergence. The plant hieght, the length and diameter of stem and the number of branches do not increase 90 days after emergence while the productive growth still continues in the period from 80 days to 120 days after emergence. The capsule number per plant and the seed number per Capsule are determined at the date of 100 days after emergence. Seeds are still in the prc-cess maturation in the period of 110 to 120 days after emergence.

2. Yield of straw, line fiber, and total fiber reaches the peak at the harvesting date of 110 days and 120 days after emergence. They are significantly higher than other harve-sting dates. However, there is no significant difference between these two treatments. Comparing these two treatments with treatment of 100 days after emergence, the yield of straw increases 4.6~8.8%, line fiber increases 11.1~14.6%, the total fiber increases 6.9~9.9%. The yield of seed reaches the peak when it is harvested at the date of 120 days after emergence. It is 14.6% and 47.6% higher than 110 and 100 days treatments respectively.

3. Among the rate of retted fiber of various harvesting times, the best are the 120-day and 110-day after emergence. The line fiber rates for these two treatments are 12.1~12.0%. They are significantly higher than other treatments. The total fiber rates for the harvesting dates at 120 and 110-day are also high, they are 16.51 and 15.99% respectively.

4. The fiber quality at 120 days after emergence is the best. The 110 days after emergence next. The tensile strengthes of line fiber in these two treatments are significantly

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1. Serial No. (Q) 588

2.3.4. Senior Agronomist, Agronomist, and Junior Agronomist, Tainan Fiber Crops Experiment Station, T.A.R.I., respectively.

better than other treatments, while the denier value of 110 days treatment is somewhat inferior. The grade of line fiber for 120 days after emergence is the best one. It is sorted in two grades, 92% in L_3 and 8% in L_4. The grades of line fiber of 110 days treatment are 75% in L_3 and 25% in L_4.

5. The relationship between the histological diagram of various tissues in the cross-section of stem and the fiber rate of various treatments is that possitive correlation was found for the percentage of phloem thickness in cross-section and percentage of pith thickness in cross-section to fiber rate. But there is negative correlation for the percentage of xylem thickness in cross-section to the fiber rate. The difference among the percentages of phloem thickness in cross-section for various harvesting dates is negligible. The percentage of xylem thickness reaches the peak at 90 days after emergence, and the other treatments show smaller values than 90-day. The percentage of pith thickness is the least one at 90 days after emergence. It increases with the dates more than 90 days, and the peak is at 120 days. This results coincide with the fact that the fiber rate increase with increasing number of days after emergence.

6. The relationship between fiber cell tissue and the tensile strength as well as denier of fibers. The growth of fibers cell tissue is performed at 100 days after emergence. At this time, the size of cell and cell wall thickness stop to increase and undergo maturity until 110 days. The cell wall thickness decreases and the lumen increases with the days. The cell size, cell wall thickness and lumen are positively correlated to the tensile strength and denier of fiber. The difference between denier values of various harvesting dates is in consistance with the difference between cell sizes. The increase of tensile strength from 80 days to 100 days is in consistance with the increase of cell size and cell wall thickness. Hence the increase of tensile strength for 110 days and 120 days is considered due to maturation of fiber cell.

7. Based on the results mentioned above, it is concluded that the flax harvesting date in Taiwan would be the most profitable at 120 days after emergence. The yields of straw and fiber are 3~4% lower than that at 110 days, but the seed yield is increased by 14.6%. The line fiber rate and cottonized tow rate are not lower than that of 110 days. The total fiber rate increases 0.52%. Although the tensile strength breaking load of line fiber decrease 0.9kg, the denier value is smaller, fiber is finer and the grade of line fiber is better than that of 110 days.

EFFECTS OF HOST VARIETY, PLANT MATURITY, SOIL TEMPERATURE, AND SOIL MOISTURE ON THE SEVERITY OF *Macrophomina* STEM ROT OF JUTE[1]

Yung-hsiung Cheng and Chin-chyu Tu[2]

Introduction

Stem rot, caused by *Macrophomina phaseoli* (Maubl.) Ashby (*Sclerotium bataticola* Maubl.), is one of the most important diseases of jute (*Corchorus capsularis*) and kenaf (*Hibiscus cannabinus*) in Taiwan (7). the organism is also known to cause root and stem diseases of many economic crops, notably charcoal rot of soybean (*Glycine mix*), corn (*Zea mays*), and sorghum (*Sorghum Vulgare*) (9), and root rot of cotton (*Gossypium hirsutum*) (4). The epidemics of *Macrophomina* diseases in relation to environmental factors has been discussed in some crops. Edmunds (2) reported that no infection in soils occurred when the available soil moisture was above 80%, but the infection, as evidenced by abundant sclerotial production, was so severe as up to 25%. Cotton plants subjected to water stress were more susceptible to the disease than plants watered normally (3). In sugar pine (*Pinus lambertiana*), infection occurs early and results in death of a large number of seedlings at 35°C (5).

According to field investigations, the incidence of *Macrophomina* stem rot of jute is especially severe when the plants are mature and almost ready for harvest. However, the significance of the environment in relation to the severity of the disease on jute is not clear. The purpose of this study was to determine the effects of jute variety, plant maturity, and some environmental factors on the severity of the disease.

Materials and Methods

M. phaseoli was originally isolated from diseased jute in 1969. A stock culture of the fungus was maintained in the laboratory by frequent transfers to fresh potato-sucrose agar (PSA) slants. To infest soil and plant with *M. phaseoli*, the inocula were prepared with the following methods : (1) Mycelial suspension—a mycelial mat of the organism grown on PSA was transfered to an Erlemeyer flask containing 100 ml of Czapeck's solution. After 5 days of incubation at 28°C, the colony was filterd and macerated in a Waring blender with 100 ml of distilled water for 30 seconds. The mycelial suspension prepared in this manner was used for direct soil inoculation. (2) Toothpick inoculum- toothpicks (diameter 0.1 cm) were autoclaved and placed on the surface of PSA in a Petri dish. A 5-mm-

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diameter mycelial mat was transfered to the central part of the Petri dish. After 5 days of incubation at 28°C, toothpicks were completely covered with mycelia and ready for the use as inocula to infest plants by inserting a toothpick into the plant.

For the comparison of the susceptibility of different ages of jute varieties, Tainoun No. 1, Tainoun No. 2, Tainoun No. 3, and Tainoun Selected No. 1 were planted in 24-cm pots filled with autoclaved soil. After seed germination, young seedlings were thinned to grow 10 plants in each pot. Different ages of jute plants were infected with mycelial suspension or toothpick inoculum. Each pot was considered as a replicate and each treatment was consisted of 4 replications. All pots were kept in the greenhouse where the temperature fluctuated around 26±2°C.

For determining the optimum soil temperature for disease development, jute seeds of the variety Tainoun No. 1 were sowed in a 18-cm metal pot containing autoclaved soil. The soil moisture was maintained at the level of about 25% moisture holding capacity. Elimination of young seedlings was made immediately after the appearance of first true leaves to allow the growth of 25 plants in each pot. These pots were then kept in the specially designed water baths to maintain constant soil temperatures of 23, 27, 31, and 35°C in the greenhouse. Inoculation was made by adding 50 ml of mycelial suspension on the soil surface of each pot, then sufficient amount of water was applied to assure even distribution of the inoculum. Noninoculated pots were served as control. Each pot was considered as a replicate and 4 replications were made for each treatment.

Effect of soil moistures on the disease development was tested with 24-cm-diameter plastic pot containing autoclaved soil. Four moisture levels, 15, 25, 35 and 45% MHC were maintained and the soil surface was covered with polyethylene sheet to prevent water evaporation. Twenty plants were planted in each pot and 4 pots were used for each treatment. Inoculation was made 30 days after planting by inserting a toothpick inoculum into stem at the part of 10 cm above the soil level. Noninoculated plants were served as control. 15 days after inoculation, disease reading were made by measuring lesions with a planimeter.

Disease index reading was made 15 days after inoculation for the investigation of root-rot type of infection. The disease groupings used were : 0=healthy ; 1=slight rotting at root tip ; 2=lateral roots heavily affected, but slight infection on main root ; 3=heavy infection and rotting on all parts of root ; 4=death of plants. The calculation method of disease index was made after Tu (6).

Results

Variety and plant maturity : Of the four jute varieties tested, none was found to be immune to the infection of *M. phaseoli*. However, to the stem-rot type of infection, Tainoun No. 3 variety showed moderate resistance, the average spot sizes on 30-, 60-, 90-, and 120-day-old plants only reached 12.67, 22.25, 22. 11, and 22.50mm^2, respectively. The most susceptible variety was Tainoun No.2, the average spot sizes on the 4 different ages of plants were 31.90, 38.25, 43. 25, and 50. 91mm^2, respectively. The disease severity also

increased with the age of plants regardless of the varieties tested(Fig. 1). Detailed results are shown in Table 1.

A similar result of varietal susceptibility was observed in the root-rot type of infection. Root-rot indexes of varieties Tainoun No. 1, Tainoun No. 2, Tainoun No. 3, and Tainoun Selected No. 1 15 days after inoculation were 20.14, 32.18, 6.53, and 8.78, respectively. No appreciable root-rot was found from the plants older than 30 days (Table 2).

Table 1. Effects of jute variety and maturity on stem-rot severity*

Variety	Plant age (days)				
	14	30	60	90	120
	Size of spot (mm^2)**				
Tainoun No. 1	0	21.67	31.38	32.63	34.69
Tainoun No. 2	0	31.90	38.25	43.16	50.96
Tainoun No. 3	0	12.67	22.25	22.11	22.50
Tainoun Selected No. 1	0	15.71	26.32	30.31	27.16

*Inoculation was performed with toothpick method.
**Size of spot was measured 15 days after inoculation.

Table 2. Effects of jute variety and maturity on root-rot severity*

Variety	Plant age (days)				
	14	30	60	90	120
	Disease index**				
Tainoun No. 1	20.14	0	0	0	0
Tainoun No. 2	32.81	0	0	0	0
Tainoun No. 3	6.53	0	0	0	0
Tainoun Selected No. 1	8.75	0	0	0	0

*Inoculation was performed with mycelial suspension.
**Disease index was calculated 15 days after inoculation.

Soil temperature : Soil temperature is an important environmental factor affecting the severity of *Macrophomina*-root rot of jute. At the lowest soil temperature (23°C), *M. phaseoli* was quite destructive and the disease index read 15 days after inoculation was 7.58. Disease severity increased with the increase of soil temperature, and the disease index read a maximum of 19.26 at 35°C (Fig. 2). All uninoculated plants were healthy throughout the period of experiment.

A test on the influence of soil temperatures on the growth of jute was also made with check plants (uninoculated). Growth of the top and root was depressed at 23°C and 35°C. The optimum growth temperature was 27°C (Fig. 3).

Soil moisture : In a preliminary study, top growth of jute was retarded at soil moisture below 25% or above 45% MHC, but it was little affected at soil moisture between

these two levels. Plant height was measured at the end of the experiment. 20 check plants grown at each of 4 moisture levels, 15, 25, 35, and 45% MHC, measured 86.3, 124.7, 148.6, and 128.6 cm in height, respectively (Fig. 4).

On the other hand, soil moisture markedly influenced the development of *Macropho-*

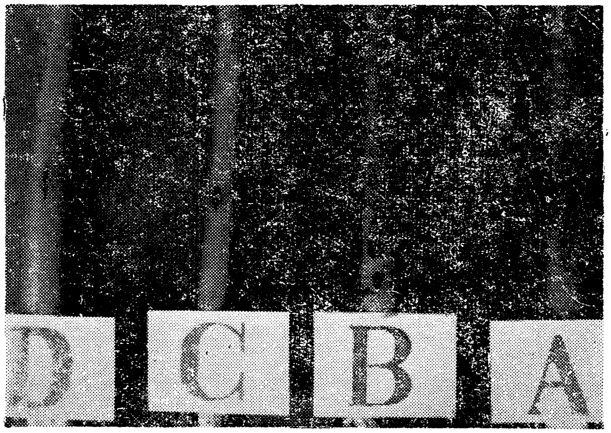

Figure 1. Successful infection with toothpick inoculum on 120-day-old jute plants of different varieties. A. Tainoun No. 1. B. Tainoun No. 2. C. Tainoun No. 3. D. Tainoun Selected No. 1.

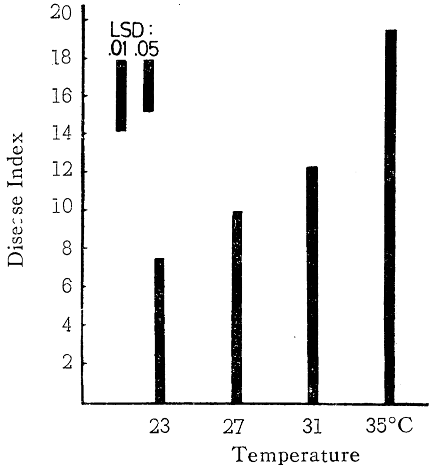

Figure 2. Influence of soil temperature on jute *Macrophomia*-root rot occurrence

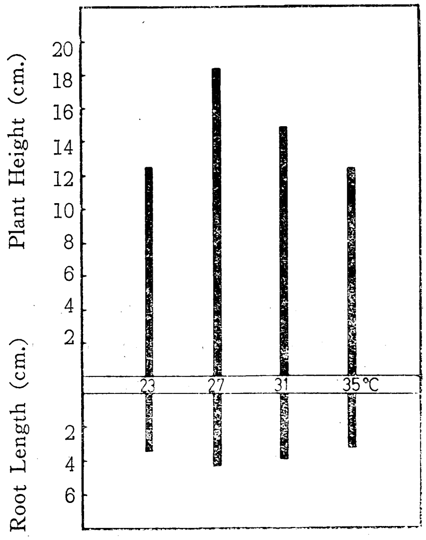

Figure. 3. Influence of soil temperature on jute growth

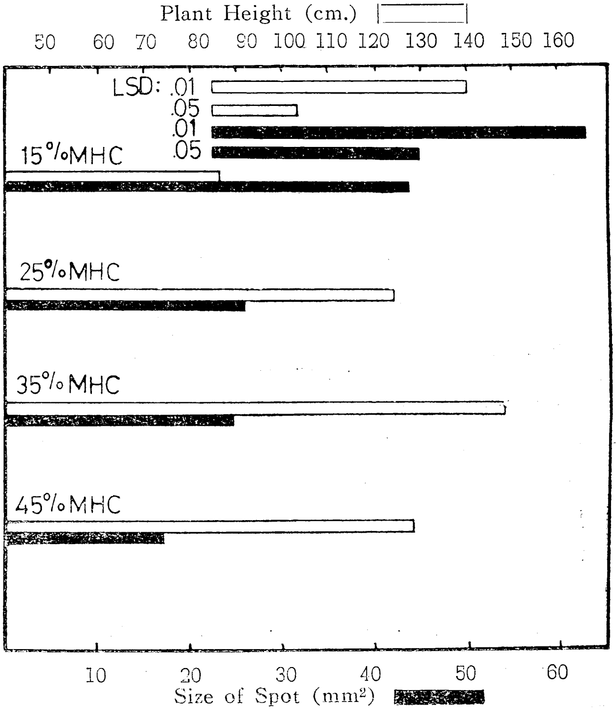

Figure. 4. Influence of soil moisture on jute growth and *Macrophomina*-stem rot development

mina-stem rot 15 days after inoculation. The average sizes of disease spots on the plants at 15, 25, 35, and 45% MHC were 44, 26, 25, and 17mm^2, respectively (Fig. 4). The uninoculated plants remained healthy in all cases. The soil temperature was also kept at 28-33°C.

At the lowest moisture level tested, the expansion of disease spot was very quick. However, the spot expansion was significantly slowed down by increasing soil moisture from 15% MHC to 45% MHC. There appeared to be an inverse relationship between disease development and soil moisture content.

Discussion and Conclusion

The results obtained in this study demonstrate that there are no commercial jute varieties completely resistant to the infection of *M. phaseoli* in Taiwan today. Of the four most widely accepted varieties tested, Tainoun No. 3 was moderately resistant, and Tainoun No. 2 was a very susceptible one. The other two varieties, Tainoun No. 1 and Tainoun Selected No. 1, were intermediate, but they were still susceptible to the disease.

Concerning the relationship between disease incidence and plant maturity, the results showed that disease susceptibility was closely related to plant age. The older the plant was, the more severe disease incidence occured. This results agreed to our field experience that jute plants after 4 months of fully growth were more susceptible to the organism, and the entire jute plants in the field destroyed by the disease was found to be not unusual. Further study on the reason of this late susceptibility is needed.

Vasudeva (8) reported that cotton *Macrophomina*-root rot was reduced at lower soil temperature. Our results revealed that the infection of *M. phaseoli* on jute was favorated by higher soil temperature (Fig. 2). The root rot index was only 7.58 at soil temperature of 23°C, then gradually increased with increase in soil temperature. At 31°C an abrupt increase in disease severity was detected. Our results also indicated that optimum temperatures for growth of jute and for infection of *M. phaseoli* were not similar ; the former was 27°C, and the latter was at 35°C. However, the average temperature during the jute harvesting period in Taiwan is about 30°C or higher. This temperature condition is unfavorable to the host but suitable to the infection of pathogen, and may explain why *M. phaseoli* causes damage mostly during the harvesting period.

Soil moisture plays an important role in the disease development of jute *Macrophomina*-stem rot. Our results strongly indicate that soil moisture has significant effect on the development of jute stem rot and that damage caused by *M. phaseoli* can be reduced by manipulation of soil moisture (Fig. 4). Crall (9) reported that infection occured more readily on mature soybean plant when soil moisture was deficient. Hence, it is almost certain that lower soil moisture is more favorable to the development of the disease.

Wyllie and Calvert (9) emphasized that infection of *M. phaseoli* on soybean was not directly related to the influence of temperature or moisture on the fungus, but rather affected by these environmental stresses on maturation of the plant. We believe that their conclusion may also be true on jute *Macrophomina*-stem rot. An effort to determine more precisely on the disease development influenced by the combination of environmental

factors and plant ages should be made further.

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黃麻品種，植株成熟度，土壤温度及土壤濕度對立枯病發生之影響[1]

程永雄、杜金池[2]

中文摘要

本省目前推廣之黃麻4品種中並無完全抗立枯病品種。臺農3號具中等抗病性，其次爲臺農選1號，再次爲臺農1號，而以臺農2號最爲感病。黃麻自發芽後14日內可因(*Macrophomina phaseoli* (Maubl) Ashby 之侵染產生嚴重幼苗根腐型立枯病，但自30日後黃麻根部對立枯病病原菌之侵染具有抵抗性，即使極感病性品種（臺農2號）亦未見有根腐型病徵。黃麻愈成熟愈容易發生莖腐型立枯病，經以牙籤接種法將病原菌接種在不同生育日數之黃麻莖部，15日後檢查罹病病斑結果，以臺農1號爲例、生長日數30日者爲 21.69mm^2，60日者爲 31.38mm^2，90日者爲 32.63 mm^2，120日者爲34.69 mm^2。土壤溫度與黃麻根腐型立枯病之發生成正相關關係。在 35°C 土溫下黃麻根腐型立枯病發生指數爲19.26，31°C爲12.3，27°C爲9.90，而以23°C最少爲7.58。土壤濕度與黃麻莖枯型立枯病之發生成負相關關係。低土壤濕度環境下較容易感染；病斑擴大快速，而在高土壤濕度環境者較有抵抗性；病斑擴大緩慢。黃麻（臺農1號）生長在不同含水量土壤1個月後接種病原菌，經15日後調查病斑大小結果，45%MHC者平均爲 17mm^2，35%MHC者爲 25mm^2，25%MHC者爲 26mm^2，而以15% MHC者病斑最大爲 44mm^2。

（1）本研究之完成第一作者曾受國家科學委員會之補助。

（2）臺南棉麻試驗分所技士及技正兼植物保護系主任。

施肥時期對香茅草產量及油分品質之影響

徐原田、楊永裕

一、前　言

近年來，本省農業發展方向之一，是栽培經濟作物，擴展外銷。本省爲香茅油主要產區，年產量多達2,000公噸左右，佔世界總產量60%以上，且油分品質佳，生產成本低，故世界各地香茅油的需求多仰給臺灣。本省由於需要量不多，故90%以上輸出國外，約佔國際市場總供應量之70%，爲本省外銷特產品之一。

本省香茅草栽培面積約13,000公頃，主產地爲臺東縣、苗栗縣以及花蓮、南投、臺中、屏東等縣。由於栽培粗放，且多爲貧瘠之山坡地，故單位面積產量不高。爲改善耕作及減少有效肥分之流失，乃舉行本試驗。目的爲探求香茅草生育期中適當的三要素肥料施用時期，以提高香茅草之含油率及油品質。

二、材料及方法

試驗材料爲本省一般栽培之爪哇型香茅草（Java type citronella grass），取自本所農場香料作物保存圃。田間設計及調查項目如下：

（一）施肥期處理　全年肥料用量爲 $N:P_2O_5:K_2O=120:60:60$ kg/ha。計分下列5種施肥期處理：

(A) N、P_2O_5 及 K_2O 肥料全部在7月中旬一次施用。

(B) N、P_2O_5及K_2O 肥料分三份，在7月中旬，10月中第一割及翌年2月中第二割後分別施用。

(C) P_2O_5 及 K_2O 肥料分作三份，施法同（B），N 肥以1/2施於7月中旬，餘1/2分三次，於每次收割前2個月施用。

(D) N肥施法同（B），P_2O_5 及 K_2O 肥料分三份，於收割前2個月分別施用。

(E) P_2O_5 及 K_2O 肥料於7月中旬一次施用， N 肥分三份，施法同（B）。

（二）試驗設計　採用完全逢機區集法，分6區集，行株距100公分×30公分，4行區，每處理小區面積4公尺×3公尺，即12平方公尺。

（三）調查項目　爲成活率、缺株、補植、株高、分蘖數、鮮草量、油量、含油率、香茅醛含量等。

三、試驗結果與討論

本試驗已進行3年，至60年6月結束。其結果如下：

（一）香茅草不同施肥期與株高之關係　據表1.資料分析，59年（第2年）試驗，香茅草株高於第2次收割調查，以（B）處理最高，（C）處理最低。第3次收割則以（A）處理最高，（B）處理次之，而以（E）處理最矮，其他處理間差異不大。平均結果以（A）處理最高，（B）處理次之，而以（E）處理最矮，其他差異不明顯。

60年（第3年）試驗，株高（見表1）第1次以（D）處理最高，（C）處理最矮。第2次以(A)處理最高，（D）處理最矮。第3次以（B）處理最高，（C）處理最矮，其他處理間差異不大。由3

本試驗報告之完成承萬所長之指正，謹此致謝。

1.試驗報告農試字第五九〇號。

2.臺灣省農業試驗所技士、技正。

次資料顯示（A）、（B）處理最高，（C）處理最矮，此表示標準施肥量在不同施肥期處理下發生明顯之差異。

（二）香茅草不同施肥期與分蘗數之關係　由表1.資料分析59年（第2年）試驗，第2次收割時調查，其分蘗數以（A）處理最多，（D）處理最少；第3次收割分蘗數以（A）處理最多，（C）處理最少。綜合2次資料顯示以（A）處理最多，（C）、（D）處理最少，其他處理間差異不大。

60年（第3年）試驗（見表1），分蘗數第1次調查以（B）處理最多，（D）處理次之，（C）處理最少；第2次調查以（A）處理最多，（C）處理最少；第3次調查以（D）處理最多，（C）處理最少。綜合3次資料，第2次調查分蘗數約爲第1次分蘗數之兩倍，第3次分蘗數又較第2次略增，可知分蘗數隨香茅草生育而顯著遞增。3次分蘗數平均結果以（A）處理最多，（C）處理最少，其他處理間差異不大。

由資料顯示施肥期不同影響香茅草對肥料吸收之差異，在生育旺盛期吸收肥料必多，否則必少，各處理間生育差異如此顯著，係受各處理間生育期不同所致。

（三）香茅草不同施肥期與產草量之關係　依據表2、之資料分析三年產草量，第1年（58年）第1次收割鮮草量以（A）處理爲最高，每公頃達2,255.3公斤，（C）處理最低，每公頃只1,222.1公斤，其他處理間差異不大。由於（A）處理係以全年用肥量在7月中一次施下，故初起鮮草量高出其他處理甚多。第二次收刈以（B）處理爲最高，每公頃達5,288.4公斤，（A）、（C）處理最低，每公頃只4,610.7公斤，其他處理間差異不大。第3次收刈鮮草量以（E）處理爲最高，每公頃達17,278.3公斤，（A）處理最低，每公頃只13,182公斤，其他處理間差異不大。由資料顯示鮮草量初起以（A）處理最高，至第2刈及第3刈漸減，綜計爲各處理中最低者。此顯示鮮草量隨肥料施用期不同而呈顯著差異；亦可知氮肥宜分次施用，既可減少流失，亦利於充分吸收利用，生育健旺，提高產量，而磷及鉀肥一次施用或分次施用並不影響鮮草產量。香茅草鮮草收量起初較低，隨生育漸旺而提高。香茅草係多年生禾本作物，其生育隨時間之長短與管理施肥有密切關係。第1年三次鮮草量係隨時間與生育而遞增，第2次鮮草收量較第1次多至兩倍以上，第3次又多於第2次，超過兩倍，可

表1　施肥時期對香茅草生育之影響

Table 1. The effects of time of fertilization on growth in Citronella grass.

處理 Treatment	株高 Plant height (cm)								
	59年 (1970)				60年 (1971)				
	第2次 2nd.	第3次 3rd.	總計 Total	平均 Mean	第1次 1st.	第2次 2nd.	第3次 3rd.	總計 Total	平均 Mean
(A)	103.8	126.3	230.1	115.1	119.9	84.0	102.0	305.9	102.0
(B)	108.6	118.8	227.4	113.7	120.1	82.5	103.3	305.9	102.0
(C)	100.3	115.5	215.8	107.9	116.0	79.8	95.6	291.4	97.1
(D)	102.7	113.8	216.5	108.3	120.4	77.3	99.2	296.9	99.0
(E)	102.5	112.8	215.3	107.7	116.2	80.5	99.1	295.8	98.6
總計 Total	517.9	587.2	1,105.1	—	592.6	404.1	499.2	1,495.9	—
平均 Mean	103.6	117.4	—	110.5	118.5	80.8	99.3	—	99.7

處　理 Treatment	分　蘖　數（枝） Tiller numbers								
	59 年（1970）				60 年（1971）				
	第2次 2nd.	第3次 3rd.	總計 Total	平均 Mean	第1次 1st.	第2次 2nd.	第3次 3rd.	總計 Total	平均 Mean
（A）	36.2	45.5	81.7	40.9	20.0	40.3	40.5	100.8	33.6
（B）	33.4	38.1	71.5	35.8	20.6	34.0	40.4	95.0	31.7
（C）	33.8	35.6	69.4	34.7	19.0	31.8	35.1	85.9	28.6
（D）	32.3	37.0	69.3	34.7	20.4	32.8	41.0	94.2	31.4
（E）	33.1	38.1	71.2	35.6	19.7	34.0	39.1	92.8	30.9
總計 Total	168.8	194.3	363.1	—	99.7	172.9	196.1	468.7	—
平均 Mean	33.8	38.9	—	36.3	19.9	34.6	39.2	—	31.2

※生育調查係59年（試驗第2年）第2次收割時開始。每年收割3次，收割同時作生育調查。每處理3行平均數（每行第1及第10株不計）．59年以2次計算。

表2　施肥時期對香茅草鮮草重之影響

Table 2. The effects of time of fertilization on yield of fresh grass in Citronella grass.

(Kg/ha)

次數 Sequence	處理 Treatment	第1年 (1969) 1st. year	第2年 (1970) 2nd. year	第3年 (1971) 3rd. year	小計 Sub total	總計 Grand total	＊處理總和
第1次 1st.	（A）	2,255.3	11,637.7	10,387.9	24,280.9		（A）=83,039.5
	（B）	1,377.6	13,748.6	11,554.4	26,680.6		（B）=87,185.8
	（C）	1,222.1	12,471.0	9,499.1	23,192.2	125,359.7	（C）=77,568.0
	（D）	1,627.6	11,998.8	10,860.0	24,486.4		（D）=79,506.6
	（E）	1,527.6	14,581.9	10,610.1	26,719.6		（E）=85,949.3
	小計 Subtotal	8,010.2	64,438.0	52,911.5	—	—	
第2次 2nd.	（A）	4,610.7	7,971.4	5,580.6	18,162.7		
	（B）	5,288.4	8,304.7	5,138.4	18,731.5		
	（C）	4,610.7	7,360.4	4,277.4	16,248.5	88,006.0	
	（D）	5,088.4	7,582.6	4,277.4	16,948.4		
	（E）	4,999.5	7,999.2	4,916.2	17,914.9		
	小計 Subtotal	24,597.7	39,218.3	24,190.0	—	—	

第3次 3rd.	(A)	13,182.0	19,636.9	7,777.0	40,595.9	199,883.5	※第1次收割期：10月中旬，第2次：2月中旬，第3次：5月中旬
	(B)	16,165.1	16,220.6	9,388.0	41,773.7		
	(C)	16,351.7	13,748.6	8,027.0	38,127.3		
	(D)	15,796.2	13,804.2	8,471.4	38,071.8		
	(E)	17,278.3	14,981.8	9,054.7	41,314.8		
	小計 Subtotal	78,773.3	78,392.1	42,718.1	—	—	
總計 Total		111,381.2	182,048.4	119,819.6	—	413,249.2	

變方分析結果如下表：

變因 Source of Var.	自由度 df.	平方和 SS	均方 MS	F值 F—Value	F 5%	F 1%
年度 Year	2	198,610,739.9	99,305,370.0	1.11	6.94	18
次數 Sequence	2	432,570,459.5	216,285,229.8	2.42	6.94	18
機差 Ea	4	357,763,830.6	89,440,957.7			
處理 Treatment	4	7,535,362.2	1,883,840.6	1.21	2.78	4.22
次數×處理 S × T	8	1,199,258.1	149,907.3	< 1	2.36	3.36
機差 Eb	24	37,446,130.6	1,560,255.4			
總計 Total	44	1,035,125,780.9				

*處理間差異不顯着

見香茅草在肥料不同處理下鮮草產量呈顯著差異。

第2年（59年）之第1次收割鮮草量以（E）處理最高，每公頃達14,581.9公斤，（A）處理最低，只11,637.7公斤，其他處理間差異不大。第2次收割鮮草量以（B)處理最高，每公頃達8,304.7公斤，（C）處理最少，只 7,360.4公斤，其他處理間差異不大。第3次收割鮮草量以（A）處理最高，每公頃達19,636.9公斤，（B）處理次之，16,220.6公斤，而以（C）處理最少，只13,748.6公斤，其他處理間差異不大。再就（A）處理言，產草量由最低而升至最高，此則香茅草生育與土中保有之肥分有關，隨着生長而大量吸收肥分，使生育快速旺盛，形成直線上升。第2年每公頃鮮草收量較第1年增加約三分之一以上，但施肥量並無增加，此係第2年香茅草生育較健旺，對肥分可充份吸收利用而增加肥料報酬率，達到單位面積生產最高境界。再就3次鮮草收量言，第1次收量較第2次收量多，而第2次收量又較第3次收量為少，而以第3次鮮草收量為最多，根據資料，係受氣候條件影響而發生顯著差異。第1次收割是在10月中，此生育期為7月開始至收割期，香茅草生育尚佳。第

２次收割是在２月中，其生育期爲11月開始，進入嚴冬季節，此期間倍受寒風吹襲，生育受阻，因而影響鮮草收量。第３次收割是在５月中，其生育期自３月開始進入溫暖春天，欣欣向榮，爲生育最佳時期，因而其鮮草量爲三次收量之冠。

第３年第１次鮮草收量以（B）處理最高，每公頃達11,554.4公斤，（C）處理最低，只9,499.1公斤，其他處理間差異不大。第２次鮮草收量以（A）處理最高，每公頃達 5,580.6公斤，（C）、（D）處理最低，只 4,277.4公斤。第３次鮮草收量以（B）處理最高，每公頃達9,388公斤，（A）處理最低，只 7,777公斤，其他處理間差異不大。由資料顯示，第３年每公頃鮮草量較第２年減少約三分之一，此趨勢指出香茅草在第３年以後產量逐年遞減，亦即生育必然漸趨衰弱。再者，香茅草在一年中有其生育最旺盛及衰弱期，影響到一年中每一次之鮮草量。據表２，第１次鮮草是在10月中收割，產量爲三次收割之冠，第２次是在２月中寒冷季節收割，故其收量最少，而在５月中溫暖季節第３次收割之鮮草量次之，是以每次收割鮮草量之多寡係受氣候，施肥期與肥料之影響。總計３年中鮮草量以（B）處理最高，每公頃達87,185.8公斤，（C）處理最低，只77,568公斤。

（四）香茅草施肥期不同與油量及含油率之關係　收油量與含油率兩者互爲相關。據表３、４資料分析結果如下：

第１年（58年）第１次收刈鮮草未予蒸餾，係由於收割後不斷下雨，鮮草腐損。第２次油量以（E）處理爲最高，每公頃達35公斤，（B）處理最低，只27.8公斤，與他處理間差異不大。第３次油量以（B）處理爲最高，每公頃達155.6公斤，（A）處理最低，只118.6公斤，其他處理間差異不大。２次油量平均以（E）處理爲最高，每公頃達94.6公斤，（B）處理次之，而以（A）處理爲最低，只73.8公斤。全年每公頃收油量亦以（E）處理爲最高，達 189.1公斤，（B）處理次之，而以（A）處理最低，只 147.5公斤，此顯示氮肥分期施用對香茅草生長之影響具有決定性關係。且含油率（見表４）亦以（E）處理最高，達 0.8%，（C）處理次之，（B）、（D）處理最低，只0.74%。由資料顯示 P_2O_5 及 K_2O 與 N 肥之施用期不同，對含油率影響顯著，亦即受N、P_2O_5及 K_2O 三種肥料施用期與施用量之多寡影響到香茅草的含油量。

第２年（59年）第１次鮮草因二次颱風影響，致使鮮草毀損。第２次油量以（E）處理最高，每公頃達80.1公斤，（C）處理最低，只63.3公斤，其他處理間差異不大。由資料顯示含油率（表４）以（E）處理最高，達１%，（B）處理最低，只 0.75%，其他處理間相差不大。第３次油量（表３）以（A）處理爲最高，每公頃達159.5公斤，（E）處理次之，（D）處理最低，只100.1公斤，含油率亦以（E）及（A）處理爲最高，達 0.81%，（B）、（D）處理最低，只0.73%。香茅草在不同處理下，每公頃年收油量（第１次由於腐損，未蒸油，只計第２次及第３次油量），以（A）處理最高，達226.6公斤，（E）處理次之，（D）處理最低，只167.6公斤，差異顯著。但在含油率方面，二次平均以（E）處理最高，達 0.91%，（B）處理最低，只0.74%，其他處理間差異不大，顯示係受三要素肥料施用期之不同，而發生明顯差異，影響鮮草收量，含油量及品質，其含油率亦發生相關之差異。

第３年（60年）第１次油量（表３）以（B）處理最高，每公頃達 98.2公斤，（A）處理最低，只81.8公斤，其他處理間相差不大。其含油率（表４）以（C）處理最高，達0.94%，（A）、（E）處理最低，只0.78%，其他處理間差異不大。第２次油量以（A）處理最高，每公頃達50.2公斤，（D）處理最低，只34.9公斤，其他處理間差異不大。含油率以（C）處理最高，達0.94%，(B) 處理最低，只0.78%，其他處理間差異不大。第３次油量以（E）處理最高，每公頃達85.3公斤，（C）處理最低，只65.6公斤，其他處理間差異不大。含油率亦以（E）處理最高，達0.94%，（C）處理最低，只 0.82%，其他處理間差異不大。本年期在不同處理下之香茅草每公頃年收油量以（B）處理最高，達222.5公斤，（E）處理次之，212.6公斤，（A）處理再次之，199.4公斤，（D）處理較低，196.5公斤，（C）處理最低，只195公斤，差異十分顯著。再就含油率言，三次含油率平均以（C）

處理最高，達 0.9%，（E）處理次之，0.88%，（A）處理再次之，0.85%，（B）處理又較低，0.84%，（D）處理最低，只0.83%，顯係受不同施肥期之影響，但 P_2O_5 及 K_2O 肥施用是否適當，則亦可影響到香茅草之含油量。

表3　施肥時期對香茅草油量的影響

Table 3. The effects of time of fertilization on oil content in Citronella grass.

(Kg/ha)

處理 Treatment	58年（1969） 1st. year				59年（1970） 2nd. year				60年（1971） 3rd. year					平均總計 Mean Total
	第2次 2nd.	第3次 3rd.	總計 Total	平均 Mean	第2次 2nd.	第3次 3rd.	總計 Total	平均 Mean	第1次 1st.	第2次 2nd.	第3次 3rd.	總計 Total	平均 Mean	
（A）	28.9	118.6	147.5	73.8	67.1	159.5	226.6	113.3	81.8	50.2	67.4	199.4	66.5	233.6
（B）	27.8	155.6	183.4	91.7	69.2	117.6	186.8	93.4	98.2	39.8	84.5	222.5	74.2	259.2
（C）	29.7	149.2	178.9	89.5	63.3	107.4	170.7	85.4	89.1	40.3	65.6	195.0	65.0	239.9
（D）	30.0	139.2	169.2	84.6	67.5	100.1	167.6	83.8	89.6	34.9	72.0	196.5	65.5	233.9
（E）	35.0	154.1	189.1	94.6	80.1	121.7	201.8	100.9	82.2	45.1	85.3	212.6	70.9	266.4
總計 Total	151.4	716.7	868.1	434.2	347.2	606.3	953.5	476.8	440.9	210.3	374.8	1,026.0	342.1	1,253.1
平均 Mean	30.3	143.3	—	86.8	69.4	121.3	—	95.4	88.2	42.1	75.0	—	68.4	—

※由於長期下雨使58年第1次鮮草腐損，無法蒸餾油分，59年第1次因2次颱風影響鮮草毀損。

由上表經變方分析結果如下：

變因 Source of Var.	自由度 Df.	平方和 SS	均方 MS	F 值 F—Value	F 5 %	F 1 %
年度 Year	2	1,896	948	11.22 *	4.46	8.65
處理 Treatment	4	242.5	60.6	0.71	3.84	7.01
機差 Error	8	676.2	84.5	—	—	—
總計 Total	14	2,814.7	—	—	—	—

* 年度間呈顯着差異，處理間差異不明顯。

表4 施肥時期對香茅草含油率的影響

Table 4. The effects of time of fertilization on percent oil in Citronella grass.

處理 Treatment	58年 (1969) (1st. year)				59 年 (1970) (2nd. year)				60 年 (1971) (3rd. year)					平均總計 Mean Total
	第2次 2nd.	第3次 3rd.	總計 Total	平均 Mean	第2次 2nd.	第3次 3rd.	總計 Total	平均 Mean	第1次 1st.	第2次 2nd.	第3次 3rd.	總計 Total	平均 Mean	
(A)	0.62	0.90	1.52	0.76	0.84	0.81	1.65	0.83	0.78	0.90	0.87	2.55	0.85	2.44
(B)	0.52	0.96	1.48	0.74	0.75	0.73	1.48	0.74	0.85	0.78	0.90	2.53	0.84	2.32
(C)	0.64	0.91	1.55	0.78	0.86	0.78	1.64	0.82	0.94	0.94	0.82	2.70	0.90	2.50
(D)	0.60	0.88	1.48	0.74	0.89	0.73	1.62	0.81	0.83	0.82	0.85	2.50	0.83	2.38
(E)	0.70	0.89	1.59	0.80	1.00	0.81	1.81	0.91	0.78	0.92	0.94	2.64	0.88	2.59
總計 Total	3.08	4.54	7.62	3.82	4.34	3.86	8.2	4.11	4.18	4.36	4.38	12.92	4.30	12.23
平均 Mean	0.62	0.91	—	0.76	0.87	0.77	—	0.82	0.84	0.87	0.88	—	0.86	—

變方分析結果如下表：

變因 Source of Var.	自由度 Df.	平方和 SS	均方 MS	F 值 F—Value	F 5 %	F 1 %
年度 Year	2	0.02	0.01	5 ※	4.46	8.65
處理 Treatment	4	0.01	0.0025	1.25	3.84	7.01
機差 Error	8	0.016	0.002	—	—	—
總計 Total	14	0.046	—	—	—	—

※年度呈顯著差異，處理差異不明顯。

表5 施肥時期對香茅草含香茅醛量的影響

Table 5. The effects of time of fertilization on Citronellal Content in Citronella grass.

處理 Treatment	58 年 (1969) (1st. year)			59 年 (1970) (2nd. year)			60 年 (1971) (3rd. year)					平均總計 Mean Total
	第3次 3rd.	總計 Total	平均 Mean	第2次 2nd.	總計 Total	平均 Mean	第1次 1st.	第2次 2nd.	第3次 3rd.	總計 Total	平均 Mean	
(A)	47.4	47.4	47.4	36.2	36.2	36.2	40.4	52.4	46.9	139.7	46.6	130.2
(B)	47.4	47.4	47.4	40.4	40.4	40.4	40.4	50.8	43.7	134.9	45.0	132.8
(C)	46.5	46.5	46.5	40.4	40.4	40.4	34.5	53.1	42.9	130.5	43.5	130.4

（D）	47.0	47.0	47.0	35.7	35.7	35.7	35.4	52.7	46.7	134.8	44.9	127.6
（E）	48.2	48.2	48.2	40.7	40.7	40.7	35.9	54.7	44.3	134.9	45.0	133.9
總 計 Total	236.5	236.5	236.5	193.4	193.4	193.4	186.6	263.7	224.5	674.8	225.0	634.9
平 均 Mean	47.3	—	47.3	38.7	—	38.7	37.3	52.7	44.9	—	45.0	—

※ 表列所缺次數係未經化驗。

變方分析結果列如下表：

變 因 Source of Var.	自由度 df.	平 方 和 SS	均 方 MS	F 值 F—Value	F 5 %	F 1 %
年 度 Year	2	199.3	99.7	34.38※	4.46	8.65
處 理 Treatment	4	8.1	4.0	1.38	3.84	7.01
機 差 Error	8	23.3	2.9	—	—	—
總 計 Total	14	230.7	—	—	—	—

※ 表示達到 1 %顯著標準。

（五）香茅草施肥期不同與香茅醛含量之關係　香茅草在不同處理下鮮草產量發生顯著差異，同時影響到收油量高低及油品質。香茅油品質佳否，主要在於香茅醛含量之高低。經化學分析結果（見表 5 ），香茅醛含量皆超過標準之35%。香茅油國際市場品質標準取決於香茅醛之高低，香茅醛不得低於35%標準。第 1 年香茅醛含量，平均以（E）處理最高，達48.2%，（A）、（B）處理次之，而以（C）處理最低，只46.5%，其他處理間差異不大。較標準高出10%以上，可見品質之佳。

第 2 年所蒸餾之油量爲第 2 次及第 3 次油量，就第 2 次油量分析（見表 5 ），其結果如下：香茅醛（Citronellal）含量以（E）處理最高達 40.7%，（D）處理最低，只35.7%，其他處理間差異不大。各處理間香茅醛含量皆超過國際標準之35%以上。

第 3 年第 1 次香茅油分析結果（見表 5 ）香茅醛含量以（A）、（B）處理最高，達40.4%，（C）處理最低，只 34.5%，其他處理間差異不大，僅（C）處理未達國際標準。第 2 次香茅油分析香茅醛含量以（E）處理爲最高，達54.7%，（B）處理最低，只50.8%，其他處理間無大差異，皆超過標準之35%甚多。第 3 次香茅油分析結果（見表 5 ），香茅醛含量以（A）處理最高，達 46.9%，（C）處理最低，只42.9%，其他處理間差異不大。作者於1968年香茅草的肥料試驗（中國園藝第十四卷第 1 、 2 期）報告中曾指出香茅油所含總醇量，受施肥之影響不明顯，而香茅油品質高低係取決於香茅醛及總醇量之含量，而本試驗之主旨爲提高香茅醛含量，上述分析結果，香茅醛含量皆超出標準甚多，在不同處理下之施肥期試驗有助於提高香茅醛含量，亦即提高油分品質。

由本項試驗，獲知鮮草量、含油量及品質以（E）及（B）處理爲最佳，（A）處理尚可，（D）

及（C）處理較差。分析結果所得資料尚稱完整，但可能受到氣候環境以及原土壤所含微量元素影響及於香茅草之含油量及品質，有待進一步研究與探討。

四、摘　要

爲探求香茅草生育期中適當的三要素肥料施用時期，以提高香茅草之含油率及油品質，舉行本試驗。自民國57年（1968）7月至60年（1971）6月，連續3年。供試材料爲本省一般栽培之爪哇型香茅草（Java type citronella grass），分5個施肥期處理。全年施肥量爲N：P_2O_5：K_2O=120：60：60 kg/ha。茲將試驗結果摘述如下：

1.就香茅草生育特性言，其株高與分蘖數隨香茅草生育而顯著遞增。但在生育中受氣候、施肥期與肥料之影響爲最。在嚴冬季節香茅草倍受影響，鮮草收量銳減。

2、3年中鮮草收量以第2年爲最多，而3年總收量（表2）則以（B）處理（N，P_2O_5 及 K_2O 肥料分三份在7月中旬，10月中第一割及2月中第二割後分別施用）爲最高，有顯著增產之效，而以（C）處理（P_2O_5 及 K_2O 肥料分三份，施法同（B），N肥以1/2施於7月中旬，餘1/2分三份，於每次收割前2個月施用）爲最低，其他處理間鮮草量差異不顯著，表示鮮草量受各種不同施肥期之影響，氮肥分次在收割後立即施用較佳，而磷、鉀肥分次施用與否，對鮮草產量影響不大。

3.各處理收油量與含油率隨年度、氣候及施肥期而互異，資料顯示3年收油量及含油率（表3、4）以（E）處理（P_2O_5 及 K_2O 肥於7月中旬一次施用，N肥分三份，施法同（B））爲最高，（B）處理次之，而以（D）處理（N肥施法同（B），P_2O_5 及 K_2O 肥分三份，於收割前2個月分別施用）最低。顯示 P_2O_5 及 K_2O 肥於每次收割前2個月施用有降低油量及含油率之趨勢。

4.香茅油（Citronella oil）之香茅醛（Citronellal）量之多寡與施肥期不同有關（表5），以（E）處理最高，顯示 P_2O_5 及 K_2O 肥宜早期施用，N肥宜分次施下，均可提高香茅醛含量。

5.各處理間香茅草之含油量及油品質受 P_2O_5 及 K_2O 肥施用時期是否適當之影響較大。

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THE EFFECT OF TIMING OF FERTILIZATIONS ON YIELD OF FRESH GRASS AND OIL CONTENT AND QUALITY IN CITRONELLA GRASS

by

Y. T. Shyu & Y. Y. Yang

The purpose of this study was to investigate the effects of the timing of fertilizations on the yield of fresh grass as well as oil content and quality of citronella oil. The experiments were conducted at Taipei for a period of three years, from July of 1968 to June, 1971. The variety, Java type of citronella grass was used. There were five different timing of fertilizations in this study. The total amount fertilizers of N, P_2O_5 K_2O were 120,60 and 60 kg/ha, respectively. The results are summarized as follows :

1. The plant height and the number of tillers of citronella grass increased with the plant growth. However, the plant growth was not only influenced by timing of fertilizations, but also by climate conditions. The yield of fresh grass was significantly decreased during the winter.
2. In the period of three years, the second year yielded the highest fresh grass. Comparing the treatments of three years average, the treatment B (split the N, P_2O_5 and K_2O fertilizer into three parts, each part of them applicated at middle July, middle Oct. (Ist harvest) and middle Feb. (2nd harvest)) obtained the highest fresh grass, and the treatment C (applicated the P_2O_5 and K_2O fertilizer as treatment B did, the ½ amount of N fertilizer applicated at middle July, split the remains into three parts, applicated each of them at two months before each harvest)harvested the lowest yield. The yields among other treatments were not significantly different. The results indicated the timing of nitrogen fertilizations affected the yield of fresh grass, the yields increased when nitrogen applied following harvesting. However, the effects of potassium and phosphorus fertilizers on fresh grass were limited.
3. The yield of oil and oil content of citronella grass varied with seasons, years and timing of fertilizations. According to the three years data, the treatment E (applicated N fertilizer as treatment B did, applicated P_2O_5 and K_2O fertilizer at middle July once) obtained the highest yield of oil and percentage of oil content, followed by the treatment B, the treatment D (applicated N fertilizer as treatment B did, Split P_2O_5 and K_2O fertilizer into three parts, applicated each part at two months before each harvest) yielded the lowest. The results showed fertilizers of potassium and phosphorus applied two months before harvest decreased the yield of oil and oil content.
4. The timing of fertilizations affected the content of citronellal in citronella oil. The treatment E showed the highest in citronellal content indicating that the quality of citronella oil can be improved by applying potassium and phosphorus fertilizers at the early stage of growth and applying nitrogen fertilizers two months before harvest.
5. The oil content of citronella grass and the quality of citronella oil was mainly influenced by the timing of potassium and phosphorus fertilizations.

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